1965

Efficient organization of the farm industry in the North Central Region of the United States in 1980

William Edward Saupe
Iowa State University

SAUPE, William Edward, 1928-
EFFICIENT ORGANIZATION OF THE FARM INDUSTRY IN THE NORTH CENTRAL REGION OF THE UNITED STATES IN 1980.

Iowa State University of Science and Technology, Ph.D., 1965
Economics, agricultural

EFFICIENT ORGANIZATION OF THE FARM INDUSTRY IN THE NORTH CENTRAL REGION OF THE UNITED STATES IN 1980

by

William Edward Saupe

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major Subject: Agricultural Economics

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Of Science and Technology
Ames, Iowa

1965

TABLE OF CONTENTS

INTRODUCTION

The Problem

The problem in this study was to estimate for 1959 and project for 1980 the resource and production characteristics of the farm industry in the North Central Region of the United States, under the condition that the requirements for economic efficiency would be satisfied. The efficient organization of the farm industry would require the satisfaction of three conditions:

a. farm output be produced at minimum factor cost,

b. aggregate farm output clear the market at prices covering the opportunity cost of the factors,

c. the product mix geared to the wants of the consumers.

Meeting these requirements would mean that the income of individual farm operators would be maximized, and the farm industry would make its maximum contribution to national income.

Income maximization is only one of several goals commonly held by farm operators and may be in direct conflict with the attainment of non-income goals. Similarly, maximizing the contribution of the farm industry to national income may directly conflict with non-income farm policy goals. When conflict among goals exists, non-income goals are attained with some sacrifice in income. To rationally decide what level of non-income goals should be enjoyed, some measure of the cost in terms of sacrificed income is required. The estimates and projections made in the present study can be used as standards to measure the opportunity costs of less than efficient organization of the farm industry.

Relevancy of the problem

Implicit in attacking this problem was the hypothesis that existing resource and production characteristics of the farm industry were not approximations to the economic efficiency conditions. It was specifically hypothesized that the farming industry contained two major types of resource imbalance in the level of farm production. The problem of product mix being geared to the wants of the consumers was not considered in the present study because of the complex nature of the problem. Additionally, the farm industry has greater internal capacity to deal with this problem since it requires only intra-firm and inter-firm shifting of resources, and does not require the movement of resources out of the farming industry.

Imbalance in resource cost It was hypothesized that more resources were used by the farming industry than necessary to produce the observed level of farm production. Stated differently, the quantity of resources committed to the farming industry could have generated larger levels of production. With this type of imbalance, the total level of farm output may or may not be optimum but is produced at greater resource cost than necessary. This prevents the farming industry from making its maximum contribution to national income.

In the absence of an imbalance in resource cost, the earnings of comparable factors would be the same on all farms. A test to support this hypothesis would be for factor returns on well organized farms to exceed the returns to comparable factors on farms that are not well organized.

In the present study, the term "well organized farms" refers to those farms having the largest positive (or least negative) excess of factor earnings over factor opportunity costs.

Evidence supporting the hypothesis that an imbalance in resource cost existed is provided by farm consolidation studies in Iowa. Farm consolidations in Hamilton County in Iowa Subregion 2 during the three year period 1952 to 1955 were investigated (1). During those three years, 69 farm consolidations took place in Hamilton County involving what were originally 137 farm units. There was a 22 percent decrease in the amount of labor used and a 27 percent decrease in the value of machinery used after the consolidations. Findings with respect to total output effects were less conclusive but indicated that following consolidation the same land area produced less livestock but at least as much and perhaps more crop production. The decrease in labor and machinery inputs and the concomitant small change in total output is evidence that more resources were used prior to consolidation than were necessary for the level of production generated.

A second consolidation study concerned four counties in Iowa Subregion 5 which took place following the 1956 crop year (2). There were 214 farm units involved in consolidations during the one year studied. Following consolidation, only 18.2 percent of the labor on the disbanded farms was added to the labor supply on the farms remaining. Additionally, only 38 percent of the total value of machines on the disbanded farms was added to the total value of machines on the remaining farms.

Total crop production from the consolidated farms was about 14 percent larger than the crop production from the same area before the mergers, but livestock production was less on the consolidated farms than on the total area prior to consolidation. This study offers additional evidence that more resources were engaged in farming in the area studied than were required to produce the observed level of production.

Evidence of the imbalance in resource cost was also found in annual farm business record summaries prepared by state experiment stations. In the published summaries, farms were often grouped by level of factor earnings. It was not unusual for groups of farms with similar quantities of inputs to differ greatly in level of production and factor earnings. These differences in efficiency were only partially explained by incomplete resource measurements.

For example, data from farms in a farm business summary in east central Iowa in 1962 were grouped into high and low one-thirds on the basis of net farm income (3). The resource inputs of the groups were $86,600 of land compared to $84,600; labor input of 18.2 months compared to 19.3 months; and livestock, feed, and machinery input of $38,800 compared to $34,000. These mean values for the groups indicate comparable bundles of inputs. The first group, however, generated $29,400 in gross production compared to $19,900 for the second group. Factor earnings for the first group were $16,000 compared to $6,600 for the second group.

A second example was based on data from hog farms in northern Illinois in 1962 that contained 180 to 259 acres (4). These farms were divided into two groups with comparable resource inputs. The mean total acres for the two groups were 216 and 220 acres; 16.3 months of labor were used by both groups; and total farm investments were $130,300 and $123,700. The value of farm production for the first group was $28,800 and for the second group was $19,400, however. Factor earnings were $15,800 and $6,600, respectively.

Additional evidence of the imbalance in resource cost in the farming industry in Iowa was provided by a study of the effects of the establishment of a relatively large manufacturing plant in a rural community in eastern Iowa (5). Two-thirds of the farmers employed in the manufacturing plant reported no change in their total farm output because of their nonfarm employment. Prior to their employment these farmers combined average per farm inputs of labor with below average inputs of land and capital to generate below average production. The labor committed to the farms had not been used productively and was underemployed prior to taking nonfarm jobs.

Imbalance in the level of farm production   The second hypothesis about resource imbalance in farming concerned the level of farm production. It was hypothesized that the quantity of resources employed in farming generated a level of farm production greater than the quantity that would clear markets at prices at which the factors of production on well-organized farms would earn their opportunity costs. Evidence supporting this hypothesis would be lower returns to factors of production on well-organized farms than in their nonfarm employment alternatives at the market-clearing prices. That is, the hypothesis would be supported if factor incomes did not equal factor opportunity costs on well-organized farms under market-clearing conditions.

Since farm product prices were not permitted to fall to market-clearing levels in recent years, the comparison of factor incomes and factor opportunity costs in well-organized farms under the observed price relationships would not necessarily be a test of the hypothesis.

Evidence supporting the hypothesis of an imbalance in the level of farm production was provided by a study of 16 well-organized Iowa farms (6). The farms analyzed were selected by Iowa's six district extension economists to represent approximations to optimally organized units under observed price conditions and technology during the two year period 1954 and 1955. The primary objective of this study was to determine whether the evidence on factor incomes and factor opportunity costs supported the hypothesis of an imbalance in the level of output.

Total factor income and factor opportunity cost per farm were calculated under several sets of assumptions. The differences between total factor income and total factor opportunity cost under the assumed set of market-clearing product prices ranged from a negative $1,300 to a negative $3,800 per farm, depending on the factor cost assumptions. The authors indicated that the study did not provide conclusive proof of an imbalance in farm output, but that the evidence in support of that hypothesis was impressive.

The existence of an imbalance in the level of farm production might be presumed from Government price support and production control activities. During each of the ten years immediately preceding this study, the Government offered price supports on corn, cotton, wheat, tobacco, butterfat, manufacturing milk, wool, barley, sorghum grain, oats, rye, flaxseed, dry edible beans, and other farm products (7, p. 540). Commodity Credit Corporation loans made to farmers served as a price supporting mechanism. These loans totaled $38.2 billion from the organization of the Corporation in 1933 through 1962 (7, p. 543).

Acreage allotments attempted to reduce the quantity of farm production. They were proclaimed by the Secretary of Agriculture for wheat, cotton, peanuts, rice, and tobacco in each of the most recent ten years, and for corn raised in the commercial area for 1954 through 1958 (7, p. 532). Acreage allotments had the effect of raising the prices of farm products to levels higher than they would have been in their absence.

The land retirement programs idled land which would have otherwise been used for crop production and had the ef´ ct of raising farm product prices by reducing the total quantity produced. In January 1963 there were 24.3 million acres under Conservation Reserve contract, about half of which was in the North Central Region of the United States (7, p. 552). The total acreage diverted from feed-grain production under the 1963 Feed-Grain Program was an additional 24.5 million acres (8). There also were 7.2 million acres diverted from wheat production to conservation uses in 1963 (9).

Prices of farm products received additional support because of the surplus disposal activities of the Government. Farm products were exported under Public Law 480 as sales for foreign currency, as disaster relief, donations, and barter for strategic materials and overseas services. Sales for foreign currency and economic aid were made under Mutual Security (AID) provisions (10). Additionally, foreign sales were made with the extension of short-term Government credit, and Government-owned commodities were sold at less than domestic market prices (11).

Domestically, some surplus commodities owned by the Government were donated to the school lunch programs, the needy, and welfare institutions.

Scope of the problem

Estimates and projections were made for each of the 71 Census of Agriculture economic subregions in the North Central Region, in a series of steps. First, the resource and production characteristics of the farm industry as it existed in 1959 were estimated. Then well-organized farms in each subregion in 1959 were identified and the farm industry reorganized on the basis of their characteristics. Third, the level of output for the reorganized farm industry in 1959 was brought into line with the level of farm product demand.

Projections of resource productivity, prices, supply, and combination and product demand in 1980 were made. Finally, the resource and production characteristics of the farm industry in 1980 were projected under conditions of minimum cost firm organization and market-clearing level of industry output.

Uses for the Estimates and Projections

The present study was a part of the North Central Regional project NC-53 concerning needed adjustments in land tenure. The resource and production characteristics of the efficiently organized farm industry that were estimated and projected in the present study were to be used as guides for determining needed changes in agricultural institutions. In succeeding phases of NC-53 the assumption of income maximization as the exclusive goal of farm operators was to be modified to allow consideration of non-income goals of farm operators.

Besides the immediate use as bench marks in further research, there were other uses for the estimates and projections. The solutions specify the conditions under which two resource imbalances in agriculture would be corrected. Economic efficiency would prevail in the farm industry under the conditions specified by the solutions, and the "farm problem" as it currently existed would essentially be solved. The solutions might thus be of interest to legislators, organizations that represent the interests of farmers, and formulators of agricultural policy and farm legislation.

If the estimates indicated that efficiently organized farms would use larger quantities of capital in 1980 than were common at the time of the study, then the solutions would be of importance to those institutions and agencies concerned with the supply of farm credit. There would be implications concerning gaining control of farm capital through means other than conventional borrowing and the leasing of capital items not commonly leased at present.

If the results indicated little change in total capital input per subregion, then there would be implications concerning the transfer of farm capital from farmers leaving the farming industry to those remaining.

If the estimates indicated increases in the per farm holdings of real estate, there would be implications concerning the ownership of real estate, the form in which control of real estate was held, intra-family and inter-generation transfers of farm real estate, other real estate transactions, and the corporate form of farm businesses.

If it was estimated that there would be increased factor earnings to the labor and management inputs per farm compared to the base period, there would be implications concerning the dispositions of the higher per capital level of farm income, including changes in the consumption patterns of farmers.

If the estimates indicated a decrease in the number of farms and farm operators, there would be implications for institutions in rural areas whose success depends on numbers of people and is only partly affected by per capita income. Schools and churches are institutions of this type.

Explicit in the study and implicit in the estimates was the condition that every farm operator was well trained in production technologies and decision making. All farmers in the solution would display management and technical capabilities comparable to those of the best farmers in the base period. This level of training would have implications for the institutions with responsibilities in the area of agricultural education.

Additionally, the number of potential farming opportunities available as indicated in the solution would have implications for those responsible for the counseling, education, and vocational training of farm youth.

Related Studies

The review of the literature indicated that the present study may be unique in its estimation of optimal farm organization and industry equilibrium obtained simultaneously. Only one comparable study was disclosed that simultaneously approached the twin problems of minimum cost farm organization and the market-clearing level of farm industry production. That was the pilot study for the present effort, which is discussed in the following section. Two other studies with some relevance are also discussed.

Southern Iowa pilot study

The present effort was preceded by a pilot study conducted in one southern Iowa subregion by Kaldor and Craft (12). The problem attacked was the same in both studies, and basic procedures were similar.

The exogenous variables were the same in the two studies, but the subregion's share of the total demand for farm products was estimated slightly differently. In the southern Iowa study, the share of demand was based on the mean historic share while historic trends in subregions' shares were considered in the present estimates.

The pilot study identified which of the Census economic classes of farms was the most optimally organized class of farms. The resource and production characteristics of this class of farms were then assumed to be the characteristics of farms meeting the criteria for economic efficiency.

The Census data were supplemented with information obtained from farm business records from southern Iowa. A group of farm business association farms were identified as being similar in structure to the selected Census class of farms, and their mean characteristics used for data that was lacking in the Census. Because of the heavy reliance upon data from farm business records to supplement Census data, it was decided that in the present study the characteristics of efficiently organized farms would be determined entirely from farm business records. With this exception research procedures and data sources developed in the pilot study were used extensively in the present study.

The stages in the research at which major assumptions and judgements had to be made were identified in the pilot study. Estimates of the 1980 values of some exogenous variables were made in the pilot study and used in the present study where appropriate.

The projections for 1980 developed in the pilot study indicated the direction and magnitude of change in structure and production that might be expected. The theoretical framework and ideal model and the necessary divergence from these norms were similar for the two studies.

Simultaneous target planning in North Carolina

A research procedure for maximizing net farm income, given specific industry restrictions was developed in North Carolina (13). The procedure was developed to correct for the omission of the effects on the farm industry in most budgeting and programming studies. Generally, if programming solutions were adopted by all farm operators the output from the geographical area would be increased and product prices would tend to fall. This would affect factor demand and factor prices. The decline in farm product prices and change in factor prices would, in turn, alter the selection of the optimal farm plan in the programming or budgeting study.

The concern about the effect on the industry of the adoption of optimal farm plans by farm operators gave the North Carolina study some relevance to the present problem. The approach basically was to determine farm organizations that would give a return to farm labor and management similar to what it could earn in nonfarm employment. The supply of human resources was treated as though it were perfectly elastic at the nonfarm price level. Returns for a geographic area were maximized to the fixed resource, land. The optimal farm plan attempted to get specified incomes for labor, management, and capital and to maximize the residual per acre return to land.

The resource structure, production, factor earnings, and return to land for typical farm organizations were determined. These characteristics were used as coefficients and the entire farm structure used as an activity in a linear programming simplex solution.

The procedure used in the North Carolina study was in some ways similar to procedures used in the present study. The present study identified the resource and production characteristics of farms from farm business record data and used these characteristics to identify appropriate farm organizations. The residual returns to land per acre were determined. It was not necessary to use these farms as activities in a linear programming solution since in the present study two conflict-ing goals were not being satisfied.

Additionally, the North Carolina study identified the characteristics of typical farms as resource restrictions. Similarly, the present study identified a bundle of capital and labor inputs associated with well-organized farms and held this bundle intact while varying the quantity of farm land associated with it.

A level of farm product prices was assumed in the North Carolina study. However, their model offered no criterion for determining the level of farm price at which farm production from the region would clear markets, or if factor earnings covered factor opportunity costs. It considered some effects of reorganization of a geographic area into optimal farms but did not consider the effects on product price and industry equilibrium.

Agricultural adjustment problem in Norwegian agriculture

The approach to a similar problem pertaining to Norwegian agriculture was described in a manuscript submitted for review prior to publication in the "Journal of Farm Economics," (14). The study attempted to calculate the total resource requirements for agricultural production, the least-cost method of production from among several farm types and the determination of "optimum prices". The author indicated that "optimum prices" would bring complete balance between total production and total market requirement.

The existing Norwegian farms were divided into 27 census classes and from 6 to 12 production activities were developed for each. These farms were included in a linear programming model. Total demand was assumed to equal the market requirements observed in 1959. The total market requirements were met with the least possible total cost subject to the restrictions and the stated coefficients in the programming model.

The solutions specified the location of production and the numbers and sizes of farms. Aggregate quantities of land and other resources were determined.

The Norwegian study was similar to the present study since it simultaneously considered optimal farm organization, total level of farm production by the industry, and the level of prices generated. The level of prices in the Norwegian solution, however, were not the prices at which production would clear the markets. Additionally, at those prices some farms made pure profits. The latter condition would stimulate entry into the farming industry which would alter the level of output and product prices and change the solution.

Linear programming models

The Norwegian model was similar in some ways to a series of programming studies pertaining to the regional location of agricultural production in the United States (15, 16). The latter models include feed-grain production, feed-wheat production, food-wheat production, soybean production, cotton production, and hog and beef production activities. Their solutions specify the location of production, the comparative price of wheat and feed grains, and land rents. Optimal individual farm organizations were not included as a part of the study.

Supply functions for dairy products were developed using variable price programming with model or representative farms (17). The supply functions did not represent farm industry output generated from minimum cost farm organization, however.

Linear programming and budgeting studies have been made in many farming regions of the North Central states using a wide variety of restrictions, activities, and coefficients. Maximization of farm income has been a common objective in linear programming studies. However, the effect of maximization of farm income on industry output, product prices, and factor prices have not been considered simultaneously to the knowledge of the author.

THE MODEL

Introduction

The problem in the present study was to estimate for 1959 and project for 1980 the resource and production characteristics of the farming industry in the North Central Region of the United States under specified conditions. These conditions were that farms would be organized at their minimum cost levels of production and that the total industry production would clear markets at prices that would just cover the factor opportunity costs.

The exogenous variables in the problem included the prices for capital, land, and for labor. Additionally, the supply of farm land available to the farm industry and the demand schedule for farm production were assumed to be given. Although considered exogenous variables to the problem, it was necessary to estimate each of these variables.

The endogenous variables were the quantity of land, labor, capital, and the level of production per farm, the value of land per acre, and the level of farm product prices. The problem was to determine the value of each of the preceding variables under the conditions specified in the study. Once obtained, the endogenous variables were used to calculate other relevant unknowns.

The farms in the solutions would be organized at the minimum resource cost level of output and the aggregate production of the farming industry would clear markets at the prices that would cover the opportunity cost of the factors used. Estimates and projections were made for 71 of the Census of Agriculture subregions in the North Central Region.

It was necessary to develop a model which would systematically explain the structure and workings of farms and the farming industry with sufficient specificity to provide quantitative values for the endogenous variables in the present study. The model was required to be a simple enough version of reality so that systematic manipulation and analysis of the data could take place. However, the model had to be a sufficiently accurate approximation of the facts for the solutions to be acceptable estimates.

In the ideal model the marginal cost of data, computer time, and professional and clerical effort would be equated with the value of the marginal return, measured in the added precision of the results. Additionally, results would be relatively insensitive to the assumptions and judgements made.

In the following sections the assumptions and variables are described briefly. An ideal model is presented in general form. The efficiency conditions for the farm industry are discussed. Finally, a brief description of procedures used in each step in making the estimates are described.

The following chapters contain detailed descriptions of the research procedures, sources of the data, and identification of judgements and assumptions made.

Assumptions

Three assumptions concerning the objectives and size of the farms were made:

a. all persons were income maximizers,

b. each farm firm bought and sold on a market so large that his activities had no effect on prices.

c. the quantity of capital and labor used by the farm industry was drawn from a market so large that the farm industry demand had no effect on prices.

As indicated previously, the assumption that income maximization was the exclusive objective of farm operators would be relaxed in later studies. It is an appropriate assumption for a first analysis, however, since some level of intensity of desire for income must be included among the goals of a farm operator if he is to continue in business over time.

The second assumption is a close approximation to reality since individual farm operators have little impact on level of farm product prices or farm costs.

Exogenous variables in the problem

The values of certain variables were considered to be known in solving the problem. These values were empirically estimated but once obtained were exogenous in the solution of the problem. They included:

a. the opportunity cost rates for capital, land, and labor,

b. the quantity of farm land available to the farm industry,

c. the quantity of farm production demanded at the 1959 farm product price level,

d. the price elasticity of demand for farm products in 1959 and 1980.

The opportunity cost rates for capital and labor were assumed to be determined outside of the farm industry, and capital and labor were considered to be in perfectly elastic supply to the farm industry at those prices. Farm capital and labor are homogeneous with their nonfarm counterparts over time, and are each relatively small portions of their total supply, supporting the reasonableness of this assumption.

The quantity of farm land available to the farm industry was assumed to be perfectly inelastic. It was assumed that nonfarm demands for farm land were price inelastic at the price level at which farm land was sold for farming purposes. That is, nonfarm demands for land would be filled from the supply of farm land, and once filled the residual supply was available exclusively for farming purposes, in a fixed quantity.

The opportunity cost rate for farm land to the farm industry would be zero under the above conditions. To the individual farm operator, however, the opportunity cost of capital invested in farm land was assumed to be given and was equal to the return he could earn on his capital in comparable investments.

It was assumed that the quantity of farm production demanded at the 1959 price level and the price elasticity of demand for production were known.

Additionally, it was assumed that the input of manager-operator effort was distinguishable from other labor inputs, that the manager-operator input was available to the farm industry in a perfectly elastic supply at the nonfarm opportunity cost rate, and that this input was limited to one full-time manager-operator per farm.

Endogenous variables in the problem

The value of each of the following endogenous variables were determined under the conditions specified in the study:

a. the quantity of land per farm,

b. the quantity of labor per farm,

c. the quantity of capital per farm,

d. the quantity of production per farm,

e. the value of land,

f. the level of farm product prices.

An Ideal Model

An ideal model can be described in general form by a system of six independent equations with six unknowns.

The exogenous variables:

P_C = price of capital input

P_{LB} = price of labor input

P_M = price of manager-operator input

$Q_M^{\ i}$ = quantity of management for the i-th farm, where i = 1,2, . . . K; K being the number of farms

$Q_{Ld}^{\ I}$ = quantity of farm land available to the farm industry

D^I = quantity of farm production demanded from the industry

The endogenous variables:

Y_i = production by the i-th firm

$Q_C{}^i$ = quantity of capital demanded by the i-th firm

$Q_{Lb}{}^i$ = quantity of labor demanded by the i-th firm

$Q_{Ld}{}^i$ = quantity of land demanded by the i-th firm

P_P = price of farm products

P_{Ld} = price of farm land

The first equation below indicates the physical relationships between farm output and inputs of capital, labor, and land. These variable inputs are combined with the quantity of manager-operator input which was fixed at one unit per farm. The usual diminishing marginal physical product relationships were generated by the application of increasing quantities of the variable inputs to the fixed input. The individual farm production function:

$$Y_i = F(Q_C{}^i,\ Q_{Lb}{}^i,\ Q_{Ld}{}^i)$$

The quantities of the variable factors demanded by the farm are functions of the prices of the factors, produce prices, and the physical relationships expressed in the production function:

$$Q_C{}^i = f_1(P_C,\ P_{Lb},\ P_{Ld},\ P_M,\ P_P,\ Y_i)$$
$$Q_{Lb}{}^i = f_2(P_C,\ P_{Lb},\ P_{Ld},\ P_M,\ P_P,\ Y_i)$$
$$Q_{Ld}{}^i = f_3(P_C,\ P_{Lb},\ P_{Ld},\ P_M,\ P_P,\ Y_i)$$

For the farm industry at equilibrium the demand for farm production equals the quantity produced:

$$D^I = S^I$$

The industry demand for land is equal to the sum of the demands for land by the K individual farms. The price of land is determined when industry demand for land equals the supply of land to the industry:

$$\sum_{i=1}^{K} Q_{Ld}^{\ i} = Q_{Ld}^{\ I}$$

Solutions to the above equations could be used to generate additional information about the farming industry. The number of farms, K, could be determined by dividing the quantity of land demanded per farm into the fixed total supply of land available. With the number of farms known, values for relevant variables could be expanded from farms to subregion or larger geographical area totals.

The above system of equations would generate estimates for the endogenous variables that would meet the criteria for efficiency in the farming industry. Those criteria are discussed in the following section.

Efficiency Conditions in the Farm Industry

Economic efficiency is concerned with quantities of production and distribution of income. In this way it is related to the satisfaction of human wants.

Three broad criteria for economic efficiency are:

a. aggregate output must be produced at minimum factor cost,

b. the output composition must be geared to the relative strength of demand,

c. the overall size of the industry must be such that factors of production earn their opportunity costs.

Additional general conditions must be met concerning leisure-work substitution and time preferences. The applications of economic theory discussed in this section are based on the concise description developed by Reder (18).

Minimum factor cost of production for the industry

Three relationships that can be specified independent of a price system must be satisfied for there to be minimum factor cost of production.

Factor-product relationships The marginal physical product of a factor used in the production of a specified product must be the same in all firms using that factor to produce that product. If this were not the case, removing a unit of the variable factor from a firm where it had a low marginal physical product would reduce the level of output by a small amount. Reallocating that same unit of variable factor to a firm where it had a higher marginal physical product would increase the level of output by a larger amount. There would be a net increase in total production from the same quantity of resources. National income would be increased, and more human wants could be satisfied.

The reallocation of resources should continue until the marginal physical product of a resource used in the production of a specified product is the same wherever that factor is used in the production of that product.

Factor-factor relationships The second relationship that must be satisfied for there to be minimum factor cost of production is that the marginal rates of substitution between two factors must be the same for all firms that use them in the production process. If this were not the case the total quantities of the two factors could be recombined so that more of one or both products, and no less of either, could be generated.

Product-product relationships among producers The third relationship that must be satisfied for there to be minimum factor cost of production is that the marginal rate of product substitution between two specified products must be the same for all firms producing those two products. The marginal rate of product substitution is the ratio of the marginal opportunity costs of producing the products, each measured in units of the foregone product. Resources are not traded between firms, but within each firm the resources can be shifted between product A and product B, for example. If one firm has a high opportunity cost of producing product A relative to the second firm, resources could be reallocated within each firm with the first firm producing relatively less of product A and the second firm relatively more. The first firm will generate a relatively large increase in production of product B by reducing his output of product A by one unit. The second firm, in increasing his output of product A by one unit will decrease his output of product B by a relatively small amount. Thus, through the reallocation of resources within firms, the total production of product A has been maintained while there has been an absolute increase in the production of product B. More total production has been generated by the same quantity of resources.

Composition of output

The second of the broad criteria for economic efficiency is that composition of output must be geared to the relative strengths of demand. Two conditions must be met for this criterion to be satisfied.

Product-product relationships among consumers The marginal rate of product substitution between two specified products must be the same for all consumers using those two products. The rationale is similar to that for the marginal rate of factor substitution among producing firms described in a preceding section. If this condition is not met among consumers, trading or redistribution of the products can result in one or both consumers having greater levels of satisfaction of human wants. Neither consumer would be worse off after the redistribution, and one or both would be better off.

Production-consumption relationships The second condition to be met concerning the composition of output is that marginal rate of product substitution be the same between the producing units and the consuming units. This brings the production pattern in line with the pattern of consumer wants. The necessity of the equality in marginal rates of product substitution among producers was defined in a preceding section. The present condition specifies at which marginal rate of product substitution the firms should produce of all the possible rates. This condition specifies that the firm must produce that particular product mix where the marginal rates of product substitution between producers and consumers is equated.

Size of the farm industry

The third of the broad criteria for economic efficiency is that the size of the industry is such that the products will clear the markets at prices that will just cover the opportunity costs of the resources in agriculture. This criterion is satisfied when two conditions are met:

a. the marginal rate of product substitution between a specified farm product and a specified nonfarm product must be the same for all consumers,

b. the marginal rate of product substitution between the specified farm product and the specified nonfarm product must be equated between the producing firms and the consumers.

Although there may be no firm producing both the farm product and the nonfarm product, the substitution can take place on the production side by substitution of resources.

These two conditions are both special cases of the conditions specified in the preceding section on composition of output. The special case in determining the size of the farm industry is that one of the products must be a farm product and the other a nonfarm product.

General conditions

Two additional conditions must be met for maximum allocative efficiency.

Leisure-effort substitution A person capable of effort has the choice between using this capability to render a direct service to himself in the form of leisure or to rent out his services for production purposes and be rewarded. For his optimum leisure-effort allocation, the value of the marginal leisure foregone to perform the last unit of productive effort will be just compensated by the reward received. For the firm that paid the reward for use of his effort, the marginal physical production generated by the last unit of effort must just equal the reward paid to the resource owner for his effort. These conditions must be met simultaneously.

Inter-temporal substitutions Resource control can be allocated over time through lending and borrowing. The optimum amount of lending or borrowing for any firm or individual to undertake is reached when the marginal rate of substitution between resource control at any two points in time is the same for every pair of decision-making units.

Second order and total conditions The above conditions are all necessary for economic efficiency. Additionally, it is necessary that product-product substitutions are made at diminishing marginal rates in consumption, and increasing marginal rates in production. Also, it must not be possible to increase satisfaction of human wants by using some other factor of production, or by producing some other product not otherwise produced.

Observed Characteristics of the Farm Industry in 1959

The estimates and projections of the resource and production characteristics of the farm industry in 1959 and 1980 were made in a series of steps. The first step was to identify the characteristics of the farm industry as it existed in each subregion in 1959. These characteristics were used to identify the existence and magnitudes of resource imbalances and as bench marks in measuring changes in farm industry characteristics as the imbalances were adjusted.

The characteristics were developed mainly from 1959 Census of Agriculture data supplemented by USDA sources and farm business association record summaries. The input totals for labor, capital, and land and the total production were estimated for each subregion. The number of farms in each subregion was known and per farm characteristics were calculated as mean values from the subregion totals. Additionally, gross production per farm, factor earnings, and factor opportunity cost per farm were calculated.

A later chapter is devoted to the sources of data, assumptions, judgements, and examples for the observed situation in 1959. The characteristics are reported for the aggregated North Central Region.

Minimum Cost Reorganization of Farms in 1959

The second step in developing the model was to identify and select well-organized farms in each subregion for 1959 and reorganize the land base in the subregion into farms with the mean characteristics of well-organized farms. In the present study, farms were considered to be well organized if they had a relatively high factor earnings to factor opportunity costs ratio.

Well-organized farms were identified from the individual farm business records kept by farms participating in the farm business associations in each state. The observed data in the individual farm record summaries were adjusted to account for the effect of abnormal weather on crop production and variations from cyclical mean prices for hogs and cattle. Additional adjustments were made in factor opportunity cost rates to insure consistency in the differentials among subregions.

Well-organized farms were identified by comparing adjusted factor earnings with adjusted factor opportunity costs. The group of well-organized farms was selected on the criterion that total factor earnings for the group equaled total factor opportunity costs. It was assumed that each of the farmers included in this select group had organized his farm business so that he was meeting the conditions for efficient organization of the firm (19, 20, 21).

The mean resource and production characteristics of the selected group of farms were calculated. The mean value of land per farm was used to divide the total value of land in the subregion into farms, each of which assumed the characteristics of well-organized farms. Subregion totals were then calculated for the resource and production characteristics.

A later chapter is devoted to the minimum cost reorganization of farms in 1959. Identification and selection of farms is discussed. Exogenous variables are identified and procedures used to calculate values for endogenous variables are specified. Deviations of these procedures from the ideal model and the rationale for the deviations are discussed. Empirical estimates are presented.

Second Reorganization to the Market-Clearing Level of Production in 1959

The first reorganization of the farm industry, described briefly in the preceding section, generated a situation in which all farms were organized at the minimum cost level of output. Total farm industry production was not necessarily equated with demand at the observed price level, however.

The purpose of the market-clearing reorganization was to equate each subregion's total production with its share of market-clearing demand in 1959, within the framework of well-organized farms.

Each subregion's share of the market-clearing level of demand in 1959 was estimated, based on a regression against time of each subregion's share of total United States farm production for each of the five preceding Census enumeration years. Evaluated for 1959, the regression provided an estimate of each subregion's share of total United States farm production, at the 1959 farm product price level.

The second reorganization involved changing the resource structure of farming by decreasing the input of capital and labor per unit of land until total production dropped to the desired market-clearing levels. The device for carrying out this extensification was a regression equation developed among the group of farms previously selected as the well-organized farms.

The regression used the input of capital and labor per unit of land as the independent variable regressed against gross production per unit of land as the dependent variable. Observations were made on the farms previously identified as being well-organized.

Given the subregion's share of total demand for farm production and the quantity of land in the subregion, the required level of production per unit of land was determined. The reduction of capital and labor input per unit of land was carried out through the regression equation until the desired production per unit of land was reached. This was the level at which total production for the subregion would just equal the subregion's share of total demand for farm production.

The rationale for removing capital and labor from farming rather than land lies in the comparison of their factor earnings in farming with their nonfarm opportunity cost. Labor and capital generally earned less in farming than in their alternative nonfarm employments. Additionally, they were relatively mobile resources.

This was not the case for farm land, however. Once the nonfarm industry had satisfied its relatively small demand for farm land, the opportunity cost of land to the farming industry approached zero. For this reason, land would not be removed from farming uses until its marginal value product approached zero.

The endogenous variables solved for in the market-clearing reorganization were the same variables that were specified by the first reorganization. In addition the residual earnings of land after labor and capital had been awarded their opportunity costs were capitalized into a land value per acre. For each level of farm product prices used, a different residual value of land was generated. The equilibrium product price level was estimated by setting the residual capitalized value of land equal to the marginal value product of land. The price level at which this phenomenon occurred was the equilibrium market-clearing price level.

The extensification of farming to reduce gross production per unit of land took place within the group of farms previously identified as being well-organized. Thus, the structure of farms after the second reorganization still met the minimum-cost criterion, as well as the industry meeting the market-clearing criterion.

The second reorganization is discussed in more detail in a separate later chapter.

Minimum Cost and Market-Clearing Reorganization in 1980

In the preceding sections the iterative procedure by which the minimum cost and market-clearing level of production for 1959 was estimated was described briefly. The same basic procedure was used to arrive at a unique solution for 1980. However, several data and exogenous variables which were given or were readily ascertained in the 1959 model had to be estimated for the 1980 model.

The factors of production, particularly capital and labor, had become more productive per unit of input in the years preceding this study. It was assumed that capital and labor would continue to increase in productivity during the 1959-1980 period. Four rates of increase in factor productivity were selected and a set of solutions for 1980 calculated for each.

The resource mix used in farming had also undergone change in the years preceding the present study. The direction and magnitude of these changes were determined and estimates made as to the probable farm resource mix in 1980.

In the present model the opportunity cost rates for capital in the form of farm real estate, for other capital, and for labor were considered to be generated by the nonfarm industry. The directions and magnitudes of changes in these rates in the past were determined and estimates made for their values in 1980.

The projected 1980 demand for farm production was based on the 1959 market-clearing quantities using estimated changes in population, income per capita, and export demand as the demand shifters. Total estimated 1980 demand for farm production was allocated among subregions on the basis of the evaluated trend in their share of total United States farm production.

The quantity of farm land which would be removed from the supply of land for nonfarm use during the 1959-1980 period was estimated. It was assumed that the nonfarm sources of demand for land were price inelastic and when they were filled the supply of land to the farming industry was fixed.

Once estimated, the above variables were considered exogenous to the problem, and the values of the endogenous variables were calculated as in the 1959 second reorganization. The residual to land was capitalized into a value per acre and equated with the marginal value product of land. This determined the equilibrium solution to the problem.

In the unique solution, farms were organized at their minimum cost level of production, capital and labor earned their opportunity costs, the residual capitalized into a land value equaled the marginal value product of land, and the total industry production cleared the market at the indicated price level.

A unique equilibrium solution was calculated for each of the four rates of increase in factor productivity.

The 1980 minimum cost and market-clearing reorganization is discussed in detail in a later chapter.

CHARACTERISTICS OF THE FARMING INDUSTRY IN 1959

In this chapter the resource and production characteristics of the farming industry in the North Central states are reported as they existed in the base year, 1959. The major source of information was the 1959 Census of Agriculture, with USDA data and farm business association record summaries used to supplement the data.

The chapter is divided into four broad sections. The first section reports the measurement of the volume of farm output as gross production. The second section identifies farm operating expenses and contains the calculations for determining factor earnings. The third section reports the factor inputs, and the fourth section reports the factor opportunity costs.

In each section the sources of data, estimation procedures used, and the rationale underlying the assumptions and judgements are described. Examples illustrating the procedures are included.

Empirical results for the aggregated North Central Region are included in the present chapter and for interstate Census subregions in the later chapter on results. Supplementary data and results for intra-state subregions are included in a supplementary publication (22).

Volume of Production

Volume of production or gross production was calculated as the value of crop production plus value added by livestock.

Crop production

Gross crop production was the sum of the observed value of crops produced in 1959 adjusted to a normal weather basis, plus the value of government payments received by farmers for withholding land from crop production in 1959. The government payments for withholding cropland from production in 1959 were included because they represented the approximate returns to a cropping alternative foregone by the farmer.

The quantity of each crop produced in 1959 was available by subregions (23), and the season average price received by farmers was available by states (24, 7). The observed value of crop production was calculated using these data.

The observed value of production of each major crop in every subregion was adjusted, using weather indexes, to a level representing the estimated value of production under normal weather conditions. This reduced the probability that factor productivity was distorted by unusually good or bad weather.

The observed value of crops produced in Iowa Subregion 1 are reported in Table 1 as an example of the procedure used.

Weather indexes In calculating the quantity of farm production in 1959 and other years, consideration was given to the effects of non-normal weather on per acre yields and total crop production. The productivity of resources employed would not have been accurately measured if weather was particularly favorable or unfavorable for crop production.

Weather indexes were calculated for each subregion for all major crops. This recognized weather variability within, as well as among,

Table 1. Value of crops produced in Iowa Subregion 1 in 1959

Crop	Quantity	Price	Value	Weather adjustment
Cropland used for pasture, acres	529,410	$17.30	$ 9,211,734	--
Woodland pastured, acres	376,373	9.20	3,462,632	--
Other pasture, acres	1,136,795	9.20	10,458,514	--
Corn harvested, bu.	64,275,530	.95	61,061,754	$ -604,511
Forage sorghum, acres	4,842	27.00	130,734	--
Sorghum for grain, bu.	621,210	.84	521,816	--
Wheat, bu.	617,278	1.76	1,086,409	--
Oats, bu.	11,827,837	.62	7,333,259	+725,259
Barley, bu.	20,575	.79	16.254	--
Soybeans, bu.	8,009,555	1.93	15,458,441	+813,114
Alfalfa hay, tons	960,897	13.90	13,356,468	-1,535,994
Clover and grass, etc. hay, tons	383,343	12.50	4,791,788	-551,056
Small grain hay, acres	7,722	26.70	206,177	-23,710
Other hay, tons	11,387	16.40	186,747	-21,476
Grass silage, acres	7,584	31.10	235,862	--
Irish potatoes, bu.	24,945	2.05	51,137	--
Popcorn, lbs. of earn corn	387,275	.024	9,295	--
Vegetables, sales in dollars	--	--	41,785	--
Observed total production	--	--	$127,620,806	--
Weather adjustment	--	--		$-1,198,374
Adjusted total production	--	--	$126,422,432	--

states and the unequal effect of weather on different crops.

The weather index for a particular crop for a given year was calculated by dividing the observed crop yield per acre by the normal crop yield per acre:

$$\text{Weather index} = \frac{\text{Observed yield per acre}}{\text{Normal yield per acre}}$$

For example, the observed corn yield in Iowa Subregion 1 was 66.2 bushels per acre in 1962. The normal yield was estimated to be 54.4 bushels per acre. The weather index for corn, for Iowa Subregion 1, for 1962 was calculated to be 1.22:

$$\frac{\text{66.2 bushels observed yield}}{\text{54.4 bushels normal yield}} = 1.22$$

The normal yield used in calculating the weather indexes was an estimate of the yield in the absence of short-run weather deviations during that crop production period. That is, normal yield can be represented by a trend line in per acre yields over time, with the weather index measuring the magnitude of observed yield deviations from the trend line. The slope of the trend line represents the combined effect of all variables influencing crop yields per acre over time. These include the changing form and level of capital and labor inputs on land, as well as weather cycles or trends.

The trend lines representing normal yields were estimated in two steps. First, the slope of the trend line was estimated on a state basis. Then a point on the trend line was estimated for each subregion. Given these two variables, the trend line could be estimated.

<u>Slope of the trend line</u> It was assumed that the variables affecting the slope of the trend line would have relatively uniform impact within a state, but might vary between states. A linear trend

line was fitted to state yield data for a series of years using the least-squares regression technique. The b-value obtained using state data was used as the slope of the trend lines for that crop in all subregions in that state.

The b-value was very sensitive to the time period selected. For example, Iowa experienced unusually low state average corn yields of 23 and 18 bushels per acre in 1934 and 1936 and unusually high yields of 76, 77 and 80 bushels per acre in 1961, 1962, and 1963. The mean yield for that 30 year period was 53 bushels per acre. A linear regression fitted to Iowa corn yield data from 1934 through 1963 included these five unusual years and had a slope of 1.13 bushels per year. However, a regression fitted to the years 1937 through 1960 yielded a trend line with a slope of only .495. Removing two years of low yields from the beginning of the time period and three years of high yields from the end of the time period resulted in a function with less than half the slope. A similar situation in crop yields existed throughout the region.

Since the purpose in developing the trend line was to estimate yields produced with normal weather, a time period relatively free of years with unusual yields was selected. The 24 year period from 1937 through 1960 was selected and the b-values were obtained from linear regressions fitted to yield data for those years.

<u>Locating a point on the trend line</u> Points on the trend line were estimated for every major crop in each subregion. The mean yield per acre for the 5 year period 1956 through 1960 was calculated. It was assumed that this mean was the normal yield for the median year in that

period, 1958, and that this was a point on the linear trend line. Using the b-value for the state, normal yield for any other year could then be estimated.

Crop yields were available by subregions only for the Census years. Annual yields were reported for the state crop reporting districts used by the USDA Statistical Reporting Service but they did not correspond well with Census subregions. It was necessary to develop subregion mean yields by aggregating county yield data (25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37). The calculation of b-values by states was based on state yield data (38, 39, 40, 41, 42, 43, 44, 45, 46).

To illustrate the procedure followed, the point on the trend line for corn for Iowa Subregion 1 was estimated in the following manner. The mean yield for the 5 year period, 1956 through 1960, was determined by summing total corn production in the counties included in Subregion 1, and dividing by the total acres. The counties included were Guthrie, Adair, Adams, Taylor, Wapello, Jefferson, Davis, Van Buren, and all of the counties in the South Central Crop Reporting District (31). This weighted mean was 52.4 bushels per acre. It was assumed that this was the normal yield for the median year of this series, 1958.

In general form, normal yield was estimated by

$$\hat{Y} = a + bX$$

where, $\hat{Y}$ was the estimated normal yield of a given year, a was the 1958 normal yield, b was the slope coefficient, and X was the time interval in years between 1958 and the year for which the estimate was being made In the following examples, X = 1 when estimating the 1959 normal yield and X = 4 when estimating the 1962 normal yield. For years preceding 1958, negative values would be used.

Since the b-value represents the annual bushel increment in yield per acre, the 1959 normal yield was estimated by summing the 1958 normal yield plus one times the b-value:

$$52.4 + 1(.495) = 52.895 \text{ bushels}$$

Normal yield for 1962 was estimated as follows:

$$52.4 + 4(.495) = 54.38 \text{ bushels}$$

Other weather index studies Using the mean yields for a recent several year period as an estimate of normal yield would have been vulnerable to the chance occurrence of consecutive abnormal yields (47). Use of the b-value rate of change coefficient in the present study reduced that vulnerability.

Using yield data from experiment station test plots would have had the advantage of a higher probability of the trend line being linear than under farm conditions (48). In the latter case, the rate of change in yield may be irregular as the form and level of capital inputs on land were altered in response to changing cost-price relationships and the changing capital and risk positions of farm operators.

However, experiment station plot yield data were collected from a limited geographical area. The effect would be to have a small sample size in acres observed in relation to the population of total acres in the subregion. Variability in weather between the experiment station and the rest of the subregion would make this procedure subject to error.

Predictive procedures for *ex ante* estimation of crop yields were not well suited to *ex post* estimation of normal yields (49, 50, 51).

Value added by livestock production

The value added to gross farm production by livestock was calculated by determining net livestock increase and subtracting from it the value of feed fed to livestock.

Net livestock increase was the sum of livestock and livestock products sold and consumed in the home, minus livestock purchases, and plus or minus livestock inventory changes.

The value of feed fed to livestock was estimated by summing the opening inventory of feeds, feed purchased, and crops produced, and subtracting from this total the value of closing inventory of feeds, crops sold and crops used for seed or consumed in the home. This residual was the disappearance of feed during the accounting period plus the effect of any errors, and was considered to be the value of feed fed to livestock.

Net livestock increase calculated in the above manner, reduced by the estimated value of feed fed, was considered to be the value added to gross production by livestock in the present study. The procedures used to acquire the needed data are explained in the following sections.

Livestock and livestock products sold The value of livestock and livestock products sold in 1959 was reported by subregions by kinds of livestock (23). The value of hogs and pigs sold and of cattle and calves sold were adjusted in both price and quantity to correspond to cyclical mean levels. This reduced the probability that factor productivity was affected by unusually favorable or unfavorable product prices.

The adjustment in hog and cattle numbers made it necessary to adjust the quantity of feed fed to livestock. The concentrate-equivalent of the adjustment in quantity of feed fed was estimated and its value added to or subtracted from livestock sales (52). This accounted for changes in quantities of feed sold, purchased, and fed that would have occurred had livestock numbers actually been changed.

Livestock and livestock product sales were the sum of the observed sales with cyclical price and quantity adjustments made on the value of hog and cattle sales, plus or minus the value of the adjustment in feed fed caused by the adjustments in hog and cattle numbers.

To illustrate the procedure, the data for Iowa Subregion 1 are used in Table 2.

Table 2. Adjusted value of livestock and livestock products sold in Iowa Subregion 1 in 1959

Class of livestock	Value of sales	
Hogs and pigs (observed)	$58,431,780	
Hogs and pigs (price and quantity adjusted)		$ 62,726,516
Cattle and calves (observed)	73,236,294	
Cattle and calves (price and quantity adjusted)		68,915,353
Sheep and lambs		5,227,935
Milk sold		12,592,493
Chickens including broilers		565,213
Chicken eggs		5,532,823
Miscellaneous poultry products		2,684,651
Horses and mules sold alive		310,404
Goats and kids sold alive		0
Wool short		1,174,186
Mohair		0
Feed adjustment		- 36,929
Total adjusted value of livestock and livestock products sold		$159,692,645

There was an estimated reduction in the number of hogs sold of 139,068 and an increase of 42,205 cattle sold. This shift resulted in a net increase in the quantity of corn equivalent fed of about 38,873 bushels. At the average price received by farmers of $.95 per bushel, this corn equivalent would have cost $36,929 and was subtracted from livestock sales as the value of feed adjustment.

The total adjusted value of livestock and livestock product sales in Iowa Subregion 1 was $159,692,645 in 1959, after the adjustments in prices and quantities of hogs and cattle sales and concomitant feed adjustments were made.

The numbers of both hogs and cattle tend to fluctuate over time in cyclical patterns. For hogs, the complete cycle from peak to peak lasts from three to five years; for cattle it takes a longer time.

To accurately measure the productivity of the resources used on farms, it was necessary to adjust the total revenue from hogs and cattle for the cyclical effects. Otherwise, the productivity of resources would have been obscured by cyclical effects on hog and cattle prices.

Cyclical hog adjustments The first step was to identify the hog cycle. Data for hog inventories on United States farms were published as of January 1 of each year (24, 7, 53). Hog cycles were identified by the fluctuations in the January 1 numbers of hogs on farms.

The seven years beginning January 1, 1956, and ending December 31, 1963, represented two successive hog cycles. January 1, 1956, was the peak in a hog cycle with hog numbers exceeding 55 million head. 1956 was a year of declining hog numbers with the valley in the hog cycle reached January 1, 1958, with about 51 1/2 million head. The second peak, representing the end of the first cycle, was reached on January 1, 1960, with over 59 million head reported. The valley on this second cycle was recorded January 1, 1961, and the final peak was reached on December 31, 1962, when hog numbers exceeded 56.9 million head.

The base year in our study, 1959, was the median year in these two successive hog cycles, 1956-1963.

Mean United States hog prices held a near constant relationship with the prices of other farm products during this seven year period. The ratio of the index of farm prices received by farmers for all farm products to the mean United States price for hogs remained about constant. It was not necessary to adjust hog prices to compensate for a trend in the index of all farm prices received.

The mean price received per hundredweight for all hogs sold in the United States during the 1956-63 hog cycle was $16.32. The observed price received for all hogs in the United States in the base year, 1959, was $14.10. The price difference was $2.20 per hundred. Dividing $2.20 by $14.10 equaled .156. That is, a 15.6 percent price rise was needed to raise the 1959 observed price to the mean cyclical hog price.

To calculate the decrease in hog production that would have been required to raise prices 15.6 percent, the price elasticity of farm level demand for hogs developed by Brandow was used (54). The price elasticity was -.4578. The product of .156 multiplied by -.4578 equalled -.071417. This decrease, 7.14 percent, was the decrease in hog numbers that would have been required to accomplish the $2.20 per hundredweight price rise in 1959.

Cyclical beef cattle adjustments The cattle cycle was typically longer length than the hog cycle. The two most recently completed cattle cycles each took 6 years from the valley to the following peak in cattle numbers.

Using January 1 inventories, cattle on farms and ranches recorded a low on January 1, 1938. The following high was recorded six years later on January 1, 1944.

The next low on January 1, 1949, was followed by a peak six years later on January 1, 1955. The most recent low was January 1, 1958. The inventory on January 1 of each succeeding year since then showed an increase over the immediately preceding year, including the last available data for January 1, 1964.

In the present study, the cattle cycle was defined as the period from January 1, 1955, to January 1, 1964. This was a nine year cycle, starting from a peak in numbers on January 1, 1955, with the valley occurring on January 1, 1958.

The mean price received per hundredweight for all beef cattle sold during this nine year period was $19.38 per hundredweight. The observed price received for all beef cattle sold in the United States in the base year, 1959, was $22.60. The price difference was $3.22 above the cyclical mean price level. This was 14.25 percent and indicated the decline from 1959 prices necessary to reach the cyclical mean level. To calculate the increase in beef cattle production that would have been required to depress prices 14.25 percent, the price elasticity of farm level of demand for cattle was used. In the previously cited publication, this price elasticity is given as -.6836.

The price elasticity, -.6836 multiplied by the percent decrease in prices needed -.1425, equalled .0974. The latter figure is the increase in beef cattle sold that would have caused the 14.25 percent decline in price.

Concomitant adjustments in feed use In calculating the value of total livestock and livestock products sold, price and quantity adjusters were used to adjust the observed values of hog and cattle sales. This took into account both the price change required for the 1959 price to equal the cyclical mean price and the associated quantity changes required to bring about that price change.

Additionally, the effect of the changes in hog and cattle numbers on the quantity of feed consumed was estimated. The required changes in numbers of hogs and cattle were estimated and converted into uniform grain-consuming animal units to facilitate estimating the net change in corn equivalent consumption (52). The value of the change in consumption was determined and included as a positive or negative value in calculating the total value of livestock and livestock products sold.

The value of the change in concentrate consumption was greatest in central and southern Nebraska, where a net increase of $9.7 million in concentrate cost was estimated. Total adjusted value of livestock sales exceeded $343 million in that subregion. Central Indiana experienced the largest decrease in concentrate cost, resulting from a relatively large hog decrease and small cattle increase. The decrease in feed cost was $3.4 million, compared to a total adjusted value of livestock sales of $267 million. The changes in concentrate cost were generally small percentages of the total livestock sales in their respective subregions.

Home consumption of livestock and livestock products The value of several types of livestock and livestock products consumed on the farm where produced were reported separately by states for 1959 (7). These included cattle and calves, hogs, sheep, milk and butter, chickens, eggs, and turkeys. These values were summed and divided by the total number of farms in the state to determine a mean value per farm.

It was assumed that the consumption per farm was an appropriate estimator of the consumption per commercial farm. Consumption per farm was multiplied times the number of commercial farms in the subregion to estimate the total value of home-consumed livestock and livestock products for that subregion.

To illustrate the procedure, the data for Iowa are reported in Table 3.

Livestock purchased

The value of total livestock purchased was reported by subregions for 1959 but was not disaggregated by classes of livestock (23). It was necessary to determine the value of cattle and hogs purchased so that price adjustments could be made to approximate cyclical mean prices. These data were not readily available and were estimated in the following manner.

Cattle and hogs purchased for feeding were reported separately from

Table 3. Value of home-consumed livestock and livestock products in Iowa in 1959

Description	Value of home consumption
Cattle and calves	$16,263,000
Hogs	10,118,000
Sheep	57,000
Milk and butter	8,761,000
Chickens	1,494,000
Eggs	5,398,000
Turkeys	45,000
Total	$53,200,000
Total number of farms in Iowa	174,707
Total value of home consumption per farm	$241
Number of commercial farms in Iowa Subregion 1	21,799
Total value of home-consumed livestock products on commercial farms in Iowa Subregion 1	$5,257,483

cattle and hogs purchased for other uses in a 1956 study of livestock marketing in the North Central Region (55). These data were reported by states.

Inshipments of cattle and hogs into states were reported by years by another source (7). It was assumed that all inshipments into states thus reported were feeder livestock, and the changes in numbers between 1956 and 1959 were entirely reflected in the numbers of feeder livestock. The changes in number were valued at mean prices per head and this value summed with the 1956 value for the estimated 1959 value.

It was assumed that purchases of cattle and hogs for other uses did not materially change from 1956 to 1959.

Table 4. Estimated cattle purchased for feeders and for other purposes in Iowa in 1959

Item	Number
1956:	
Total cattle purchased for feeders	2,605,000
Total cattle purchased for other uses	178,000
Changes in inshipments of cattle 1956 to 1959:	
Total inshipments of cattle 1956	2,127,000
Total inshipments of cattle 1959	2,648,000
Change in inshipments 1956 to 1959	+521,000
1959:	
Total cattle purchased for feeders 1956	2,605,000
Change in inshipments 1956 to 1959	+521,000
Estimated total cattle purchased for feeders 1959	3,126,178
Estimated cattle purchased for other uses 1959	178,000

Data for Iowa are used in Table 4 to illustrate the procedure used.

The estimated numbers of cattle purchased were converted into value of cattle purchased by multiplying by mean values per head. This estimate of total value of cattle purchased was then adjusted to account for cyclical variation in cattle prices.

The value of hogs purchased was estimated using the same procedure, and total value of hogs purchased was adjusted to account for cyclical variation in hog prices. The state totals for hogs and cattle purchased were allocated among the subregions on the basis of the percent of the state total livestock purchased observed in each subregion in 1959. This percent was established from data available by subregions for 1959 (23).

Table 5. Observed and adjusted total livestock purchased in Iowa subregions in 1959

Subregion	Observed 1959 livestock purchases	Adjusted 1959 livestock purchases
Subregion 1	$ 29,336,000	$ 28,118,000
Subregion 2	105,167,000	100,802,000
Subregion 3	54,448,000	52,188,000
Subregion 4	155,056,000	148,619,000
Subregion 5	188,446,000	180,623,000

The observed and adjusted totals for Iowa for livestock purchased by subregions are presented in Table 5.

Livestock inventories The numbers of livestock on farms during the 1959 Agricultural Census enumeration period were reported by subregions for five major classes of livestock (23). These classes of livestock were cattle and calves, hogs and pigs, sheep and lambs, horses and mules, and chickens 4 months old and older. The proportion of the state total observed in each subregion for each class of livestock was determined.

These proportions were used to allocate the value of each class of livestock reported in the state on January 1, 1959, and on December 31, 1959, among the subregions (7). An example using Iowa data on cattle and calves is presented in Table 6.

Table 6. Allocation of a share of total Iowa cattle inventories to Iowa Subregion 1

Description	Value
Total cattle and calves on Iowa farms during the 1959 Census enumeration	6,551,904 head
Total cattle and calves on Iowa Subregion 1 farms during the Census enumeration	860,615 head
Percent of state total in Subregion 1	13.137%
Total value of cattle and calves on Iowa farms January 1, 1959	$1,026,152,000
13.137% allocated to Iowa Subregion 1	134,805,588
Total value of cattle and calves on Iowa farms December 31, 1959	$1,045,620,000
13.137% allocated to Iowa Subregion 1	137,363,099

The January 1 and December 31, 1959, inventory values for hogs and pigs, sheep and lambs, horses and mules, and chickens 4 months old and older were estimated using the same procedure.

The value of hog and cattle inventories were price adjusted to account for differences from cyclical mean prices. The five classes of livestock were then summed to obtain subregion inventory totals for January 1 and December 31, 1959.

Feed and crop inventories and feed purchased Data concerning the stocks of feed and crops owned by farmers and held on farms on January 1 of each year were available for the United States for each of the major crops (7) but had to be estimated for each subregion. These crops included corn, grain sorghum, soybeans, oats, barley, flax, and wheat.

The total United States production of each of these crops was also known, and the proportion of the January 1 and December 31 stocks to total production were calculated for 1959.

The total United States production of corn in 1959 was 3,824,598,000 bushels. The farmer-owned stocks were 2,981,490,000 bushels on December 31, 1959. The proportion of December 31 stocks to production was .7796.

Data concerning 1959 crop production was available by subregions (23), and the quantity stored in each subregion was estimated using the above proportion. This procedure assumed that the percent of the 1959 crop that was stored on farms was uniform among the subregions.

In Iowa Subregion 1, for example, 1959 corn production was valued at $61,061,754 and the December 31 farmer-owned stock was estimated to be .7796 of that, or $47,603,743.

The proportion of the January 1, 1959, farmer-owned stocks to the 1958 crop production was calculated and used in the same manner. This assumed that production and disappearance of the crop in 1959 occurred in a pattern among subregions similar to production and disappearance of the crop in 1958.

Feed and crop inventories were calculated for the major crops using the above procedures for all subregions. Data on feed purchased were available from the 1959 Census of Agriculture (23).

Value of crops home consumed The total value of livestock and livestock products and crops home consumed were reported by states for 1959 (56). The value of livestock and livestock products home consumed were estimated in a preceding section. The difference was divided by the number of all farms in the state. This per farm value was used as the estimator for the level of home consumed crops per commercial farm.

The value of home-consumed crops per farm were multiplied by the number of commercial farms in the subregion to arrive at an estimate of the total home-consumed crops.

Home-raised crops used for seed   The value of home-raised crops used for seed for ten crops were available for 1959 (33). These did not include oats or barley, which were estimated by multiplying the total acres raised times the average seeding rate to determine the total bushels used for seed. The quantity used for seed was multiplied times the average price received by farmers, giving an estimate of the total value used for seed.

The calculations for Iowa are contained in Table 7.

Table 7. Value of home-raised crops used for seed in Iowa in 1959

Crop	Value
Wheat	$ 288,640
Rye	8,820
Flaxseed	27,000
Soybeans	3,831,460
Dry edible beans	0
Alfalfa seed	0
Red clover seed	710,016
Sweetclover seed	10,744
Lespedeza seed	0
Timothy seed	74,992
Oats	8,905,548
Barley	49,588
State total	$13,907,808

The state total was allocated among the subregions on the basis of crop acres per subregion as a percent of the total crop acres in the state.

Crops sold The aggregate value of all crops sold was reported by subregions for 1959 (23). This total was adjusted to a level representing sales under conditions of normal weather by using the same weather adjustment used in adjusting gross crop production. For Iowa Subregion 1 the reported crop sales were $38,973,297. The weather adjustment was -$1,198,374, and the adjusted crop sales was the difference, or $37,774,923.

Feed and livestock purchased Expenditures for these two items were reported by subregions in the 1959 Census of Agriculture (23). Feed purchased included expenditures for grain, hay, millfeeds, pasture, salt, minerals, and grinding and mixing of feed.

Livestock and poultry purchased included the cost of baby chicks and turkey poults. It excluded cost of livestock purchased for resale within 30 days which was considered to be a dealer transaction rather than an agricultural transaction (57).

Volume of production by subregions in 1959

The items discussed in the preceding sections were combined in the calculation of gross production, a measure of volume of production. The calculations are illustrated in Table 8 using data from Iowa Subregion 1.

Table 3. Volume of production in Iowa Subregion 1 in 1959

Item	Value
Credits:	
Livestock sales	$159,692,645
Feed and crops sold	37,775,734
Soil bank payments	2,229,116
Livestock home consumed	5,257,483
Crops used for seed	1,785,763
Crops home consumed	1,380,531
Livestock ending inventory	186,667,492
Feed and crops ending inventory	69,020,589
Debits:	
Livestock purchased	28,118,000
Livestock beginning inventory	182,597,289
Feed and crops beginning inventory	66,519,861
Feed purchased	30,988,168
Total gross production	$155,586,035

Operating Expense and Factor Earnings

In the preceding sections the estimation of gross production as a measure of volume of output was discussed. In this case, gross production was also a measure of total revenue since the product prices used to weight the physical units of output were also the prices received in 1959.

Gross production in the total revenue sense minus operating expenses would equal factor earnings. Payments for hired labor, cash rent, and interest on borrowed money were not included in operating expenses.

Operating expenses

Several major classes of farm expenditures were reported by subregions in the 1959 Census of Agriculture (23). Of these, feed purchased and livestock purchased were used previously in calculating gross production. However, the remaining classes of expenditures included in the Census data were not inclusive enough to calculate total operating expenses. The missing expenditures were estimated from USDA data and from information contained in farm business record summaries. The sources of data and estimating procedures used are described in the following sections.

Seeds, bulbs, plants and trees Expenditures for these items were reported in the Census data. They represented the total amount spent for seeds, bulbs, plants and trees to be used on the farm operated. The value of seed grown on the farm was excluded (57).

Machine hire Expenditures were reported in the Census data and related to custom machine work and the related labor that were hired. Machine hire included such items as tractor hire, combining, silo filling, baling, corn picking, and spraying. The cost of freight or trucking, and exchange work without pay were not included (57).

Gasoline and other petroleum fuel and oil Expenditures for these items were contained in the Census data and were included only if related to farm production. The cost of petroleum products used for the family automobile operated for nonfarm business purposes and cost of petroleum products used in the farm home were not included (57).

Fertilizer and lime The quantity of fertilizer used was reported in tons per subregion in the Census report (23). The proportion of the state total that was used in each subregion was calculated from this data. Total fertilizer and lime expenditure by states was reported in USDA farm income estimates (56). The total value per state was allocated among the subregions on the basis of the subregion proportions calculated from Census data.

Other expense items Other expense items were not contained in Census data but were reported as state totals in the USDA data. It was necessary to develop some criteria for allocating the state totals among the subregions.

Coefficients of correlation were calculated between the individual expense items, crop acres, and total acres in 21 Census subregions. These calculations included the records from about 2,600 farms.

On the basis of the coefficients observed and their significance levels, the state totals for machinery repairs, taxes, machinery depreciation, and miscellaneous expenses were allocated among subregions on a per crop acre basis. Miscellaneous expenses included supplies, utilities, veterinary expense, insurance, and marketing expense.

Building repairs, building depreciation, and farm share of auto expense were not significantly correlated with crop acres or total acres in the majority of the subregions. For lack of a better criterion, state totals for these categories of expenses were allocated among the subregions on a per farm basis.

Factor earnings

Gross production and operating expenses were so calculated that their difference equalled factor earnings. Factor earnings were calculated for each subregion as gross production minus operating expenses.

Factor Inputs

The following sections contain the sources of data and estimating procedures used in determining the quantity and value of factor inputs by subregion in 1959.

Land

The total acres in commercial farms, the total land value, and the number of commercial farms per subregion were reported in the Census of Agriculture data (23). These data as reported were used in the present study.

Capital

Farm capital was estimated in four categories. These categories were livestock, feed, machinery, and the stock of capital required for production expenses, and are discussed in the following sections.

Livestock The procedure used to estimate the value of livestock on farms on January 1 and December 31, 1959, by subregions was included in the preceding discussion of volume of farm output. These values were adjusted since they did not accurately reflect the inventory levels held during the remainder of the year for cattle on feed and hogs.

The weight of cattle and calves on feed by states was reported for January, April, July, and October first (58). The January first weight as a proportion of the mean of the four reporting dates was calculated and used to adjust inventory values of cattle and calves on feed from the inventory values calculated in the section on volume of farm output.

Similar adjustment values were developed for hogs. State data on numbers of hogs on hand January first, sows farrowed and pigs saved by months, and farm and commercial slaughter by months were available (59). A month by month supply of hogs on farms was calculated and the mean for the year determined. The January first number as a proportion of the mean was calculated and used to adjust inventory values of hogs.

The adjustment coefficients were used in the following manner:

$$\text{Adjusted January first value} = \frac{\text{Observed January first value}}{\text{Adjustment coefficients}}$$

The values for the coefficients are reported in Table 9. The total value of livestock, adjusted as indicated for cattle and calves on feed and hogs, was part of total capital.

<u>Feed</u> Feed and crop inventories were estimated in the calculation of volume of farm production. The estimating procedures and the sources of data were reported in preceding sections. The mean of the January 1 and December 31, 1959, inventories was used as a measure of the quantity of capital held in the form of crop and feed inventories.

<u>Machinery</u> The value of machinery on farms by states was reported in the USDA farm income estimates (56). Machinery value was correlated with crop acres in the farm records of about 2,600 farmers located in 21

Table 9. Inventory adjustment coefficients for cattle on feed and hogs, by states, 1959

State	January 1 weight of cattle on feed as a proportion of mean weight of cattle on feed during the calendar year	January 1 number of hogs on farms as a proportion of mean numbers of hogs on farms during the calendar year
Ohio	1.1793	.9464
Indiana	1.1556	.9464
Illinois	1.0834	.9464
Michigan	1.0720	.9464
Wisconsin	1.2507	.9464
Minnesota	1.0286	.9257
Iowa	.9867	.9257
Missouri	1.0671	.9257
North Dakota	1.2736	.9257
South Dakota	1.1344	.9257
Nebraska	1.0444	.9257
Kansas	1.1319	.9257
Kentucky	1.0578	.9580

subregions. The coefficients were significant at the .01 level in ten subregions, at the .05 level in five additional subregions, and approached the .05 level of significance in an additional three subregions. On the basis of these correlation coefficients, machinery value reported on a state basis in the USDA data was allocated among the subregions within the states on a per crop acre basis.

<u>Stock of capital required for operating expenses</u> Expenditures of farm operators were reported in the preceding sections on operating expenses and volume of production. Farm operators required a stock of capital as a source of funds to pay production expenses as they occurred during the year. The stock of capital was reduced by the flow of operat-

ing expenses but was replenished by a flow of receipts. It was relatively common for the flow of receipts to lag behind the corresponding flow of expense by about six months in many farming activities. It appeared reasonable that a stock of capital equal to six months' production expenses would be required to operate the farm business.

In the present study, the stock of capital required for operating expenses was assumed to be one-half of the annual operating expenses, where operating expenses excluded feed, livestock, and machinery purchased, capital expenditures, and depreciation of buildings or machinery.

Labor

The quantities of operator, family, and hired labor were estimated mainly from Census data (23). Three classes of labor discussed in the following sections were summed to give the estimate of total labor input in 1959.

Operator labor The 1959 Census of Agriculture reported the number of farm operators working off their farms for specified numbers of days in 1959 but did not specify how many days they worked off their farms. These values were estimated following procedures used in the 1954 Census of Agriculture (60). Farmers were assumed to have worked on their farms as indicated in Table 10.

The number of farmers reported by the Census to be in each of the groups in the table was multiplied times the estimated months worked on farms for that group. The sum of these products was the estimated total months of operator labor.

Unpaid family labor The total input of unpaid family labor was

Table 10. Estimation of months of farm operator labor from Census of Agriculture data

Days worked off their farms	Estimated months worked on their farms
None	11 1/2 months
1-99 days	10 months
100-199 days	6 months
Over 200 days	2 months

estimated following procedures used in the 1954 Census of Agriculture. The average man-equivalents of labor by type of farm for the United States were available for that Census (60). These ranged from .19 man-equivalents of unpaid family labor per fruit-and-nut farm to .48 man-equivalents of unpaid family labor per cotton farm and were available for 12 types of farms. These coefficients were converted to months of labor by multiplying each by 12 months.

The number of farms by types for each subregion were reported in the 1959 Census of Agriculture (23). The number of each type of farm was multiplied by the months of unpaid family labor appropriate for that class. These products were summed and the sum was the estimated total months of unpaid family labor.

To illustrate the procedure, the calculations for Iowa Subregion 3 are reported in Table 11.

Table 11. Estimation of months of unpaid farm family labor from Census of Agriculture data for Iowa Subregion 3

Type of farm	Number of farms	Man-months of unpaid family labor per farm	Man-months of family labor
Cash grain farms	3,784	3.00	11,352
Tobacco farms	0	5.76	0
Cotton farms	0	5.76	0
Other field-crop farms	2	4.80	10
Vegetable farms	21	3.72	78
Fruit-and-nut farms	10	2.28	23
Poultry farms	399	3.48	1,389
Dairy farms	5,434	4.80	26,083
Livestock farms other than poultry, dairy and ranches	14,247	3.12	44,451
Livestock ranches	0	3.12	0
General farms	3,420	4.56	15,595
Miscellaneous farms	24	2.64	63
Total man-months unpaid family labor			99,044

<u>Hired labor</u> The total cash expenditure for hired labor and the average hours worked per hired person per month were reported in the 1959 Census of Agriculture (23). The average cash wage rate per month was calculated by multiplying the average hours worked by hired persons per month by the composite hourly cash farm wage rate (61). The average cash wage rate per month divided into the total cash expenditure for hired labor gave the months of hired labor. This value was the estimated total months of hired labor used as an input in 1959.

To illustrate the procedure, the calculations for Indiana Subregion 1 are used. The average hours worked by hired labor per month was reported in the Census of Agriculture to be 220 hours. The composite hourly cash farm wage rate was reported to be $.95. Their product, $209, was the estimated composite monthly cash farm wage rate.

Total expenditure for hired labor in Indiana Subregion 1 was reported by the Census to be $4,001,788 in 1959. When divided by the composite monthly wage rate this yielded an estimated hired labor input of 19,147 months.

Factor Opportunity Costs

Opportunity cost is the amount of return foregone from alternatives when a commitment of resources is made. Opportunity cost rates were estimated to approximate the opportunity cost of labor, farm land, and of farm capital in machinery, livestock, feed inventories, and a stock of capital to furnish part of the flow of funds for operating expenses.

Opportunity cost of investment in farm land

The capital opportunity cost rates were estimated using observed interest rates as guides. Interest rates paid by borrowers or received by lenders were reported by several sources for 1959 (62). Interest rates were influenced by the cost of using funds, the risk involved in making loans, costs of negotiating and servicing loans, custom and precedent, and the presence of various degrees of credit monopoly.

The investor accepted some level of risk concomitant with the use of his funds in making an investment in farm land. The appropriate opportunity cost rate would be based on the interest rate for an alternative investment with a comparable level of risk. Additionally, the investor stood to gain by an increase in value of his property in certain investments. He would accept a lower observed rate of return if he expected a real increase in the value of his asset. Farm land was this kind of investment in the estimation of some land owners, while farm mortgages did not have this characteristic (63).

Additionally, owning farm land may have provided a place of residence for the land owner, or satisfied some non-income goal in his preference structure. These benefits would also tend to lower the observed rate of return that he would accept for his farm land investment.

Three criteria were met in selecting alternative investments as guides to the appropriate opportunity cost rates. They were as follows:

a. comparable level of risk between the alternatives,

b. the probability of change in the value of the investment,

c. the investor possessed skills necessary to manage the alternative investment.

As a possible opportunity cost rate for farm land, the interest rates on farm mortgages recorded during 1959 met the third criterion. However, there was less risk premium attached to having capital in a farm mortgage than in owning farm land. There was little chance for a change in the value of the farm real estate mortgage while being held, which tended to be off-setting.

A second possible opportunity cost rate for farm land that met the first two criteria was corporate bonds of a quality such as those included in Moody's Baa group (64). Investing in corporate bonds may not have been a known alternative to owners of farm land, or they may not have possessed the skills necessary to manage this type of investment, however.

There was close similarity in interest rates in these two alternatives. The interest rates received by all lenders on farm mortgages recorded during January 1-March 31, 1959, were 5.1 percent in the Lake States, 5.17 percent in the Corn Belt, 5.03 percent in the Northern Plains, and 5.51 percent in Kentucky. The yield on Moody's Baa Corporate Bonds in 1959 was 5.05 percent (65). The close correspondence of interest rates between these two types of investments, each of which met some of the criteria for alternative investments, indicated that they approximated the opportunity cost rate for capital invested in farm real estate.

To reflect differences in opportunity cost rates among the states, the average interest rates received by all lenders on farm mortgages recorded during January 1 to March 31, 1959, was used as the approximation of the opportunity cost of investment in farm land (65). These rates for 1959 are reported in Table 12.

Opportunity cost of investment in other farm capital

The opportunity cost rate appropriate for capital invested in machinery, livestock, feed inventories, and stock of operating capital was higher than for investment in farm land. The investor in these kinds of farm capital accepted a greater risk than the investor in land.

An alternative to investing in these types of farm capital was making loans to other farm operators for these same uses, which

Table 12. Average interest rates received by all lenders on farm mortgages recorded during January 1 to March 31, 1959

State	Percent
Ohio	5.42
Indiana	5.25
Illinois	5.07
Michigan	5.34
Wisconsin	4.99
Minnesota	5.04
Iowa	4.86
Missouri	5.37
North Dakota	5.03
South Dakota	4.94
Nebraska	4.94
Kansas	5.19
Kentucky	5.51

probably carried less risk than investing directly in these types of capital. This alternative did not involve any probability concerning the change in value of the investment other than changes in the general price level. It was an alternative that a farm operator would be aware of, and one that he would have ability to manage.

The United States Farm Credit Administration reported that in 1959 the Production Credit Association average cost of loans to borrowers for the above types of loans was 6.50 percent (66). The rates represented interest less patronage refunds, service fees, cost of record searchers, and filing and releasing mortgages paid by borrowers, as a percent of average loans outstanding during the year (7). Average interest rates on nonreal estate loans reported by the Agricultural Committee, American Bankers Association were at similar levels (67).

The Agricultural Finance Branch, Farm Production Economics Division, of the USDA reported that in 1959 production loans by banks and Production Credit Associations made up about 60 percent of the nonreal estate debt obligations of farmers in the 13 states in the present study.

To reflect differences in opportunity cost rates among the states, the average of the interest rates charged by these lenders, excluding service fees, was used as the approximation of the opportunity cost of investment in these kinds of farm capital. These rates for 1959 are reported in Table 13.

Table 13. Average interest rates charged by lenders for farm production loans in 1959

State	Percent
Ohio	6.30
Indiana	6.41
Illinois	6.22
Michigan	6.64
Wisconsin	6.34
Minnesota	6.65
Iowa	6.36
Missouri	6.60
North Dakota	6.57
South Dakota	6.73
Nebraska	5.98
Kansas	6.21
Kentucky	6.00

Opportunity cost of labor input

The labor input on each farm was composed of hired labor, unpaid family labor, and the operator's input of labor-management. Measurement of the quantity of each type of labor input was discussed in a preceding section in this chapter.

The opportunity cost of each type of labor was calculated separately and are discussed in the following sections.

Hired labor

Hired labor costs were based on the monthly wage rate for hired labor reported in the 1959 Census of Agriculture (23). The reported wage rates included only the cash wage rate paid to the labor, and did not allow for the cash value of perquisites furnished by the employer. Estimates of the value of the food and housing furnished were made and added to the reported cash wage for the estimated opportunity cost of hired farm labor.

Unpaid family labor

Some family labor was superior to hired labor in productivity because it had a personal interest in the success of the farm business and additionally had received considerable training. However, some family labor was furnished by the homemaker and young children who lack physical strength compared to hired labor. Family labor may also be assigned to jobs that have a low productivity. Considering these partially offsetting points, the cash monthly wage rate of hired labor excluding the value of perquisites, was used to estimate the opportunity cost of unpaid family labor.

Operator labor-management

Several methods of evaluating the opportunity cost of the operator labor-management input were evaluated in a 1961 study by Kaldor, Beneke, and Bryant (6). They estimated that with the skills and personal resources developed from farming experience, the operators of well-organized farms would have short-run opportunities for nonfarm employment as managers of farm supply businesses or as managers of grain elevators. If the farm operators had spent the same amount of time in developing their abilities in a different kind of work instead of in farming, they could have held positions in supervisory and managerial capacities in manufacturing, wholesaling, or retailing industries. These kinds of employment were studied in an attempt to estimate the opportunity cost of the farm operator's labor-management input.

In the Kaldor et al. study, the quantity and type of capital managed was used to develop an index of management input. Capital was classified by kinds and then weighted according to the estimates of the amount of managerial ability required to manage it. Capital in land and buildings was given a weight of one, machinery and equipment was given a weight of four, and a weight of six was given to livestock inventories, feed inventories, and the stock of operating capital.

A regression of the observed managers' salaries on the weighted capital inputs in 22 farm supply firms in Iowa, using the mean figures for two years observations in measuring both variables, resulted in the following regression:

$$\hat{Y} = \$3721 + .0115\ X,$$

where Y is the expected labor-management return in dollars, and X is the sum of the weighted value of the capital inputs, in dollars. The correlation coefficient was .737769.

The above regression was used basically in the present study to estimate the opportunity cost of the operator's labor-management input.

Differences in wage levels that existed among the states were considered in estimating the intercept coefficient in the regression, since the $3,721 rate was determined for Iowa wage conditions. Differences in the value of the constant among the states were related to the wage differences that existed among the states in certain nonfarming occupations (68). The ratio between the wage rates in each of the other states to the wage rate in Iowa was calculated and multiplied times the Iowa rate to estimate the constant in each of the other states.

The nonfarming wage rates used for the comparison were the mean of the earnings of experienced male craftsmen, foremen, and kindred workers and the earnings of experienced males in professional, managerial, and kindred positions. The wage rates of these two occupational groups were nearly equal. They were occupational groups requiring levels of ability similar to those that the operator-managers of well-organized farms would possess.

The values of the constants that were developed and used are presented in Table 14.

Summary

In this chapter the estimation procedures for determining the observed characteristics of farming in 1959 were reported. The first section

Table 14. Constants developed for use in estimating opportunity costs of farm management input

State	Intercept coefficient
Ohio	$4,328
Indiana	4,142
Illinois	4,551
Michigan	4,499
Wisconsin	4,134
Minnesota	4,013
Iowa	3,721
Missouri	3,935
North Dakota	3,362
South Dakota	3,254
Nebraska	3,540
Kansas	3,826
Kentucky	3,466

described the volume of production measured as gross production. The second section reported operating costs and factor earnings, the third section the factor inputs, and the final section the factor opportunity costs.

The resource and production characteristics of farming in the North Central Region are reported in Table 15. Similar data for interstate subregions are reported in the chapter on results.

Table 15. Resource and production characteristics of farming as it existed in the North Central Region in 1959

Variable	Value
Subregion totals:	
Number of farms	1,171,089
Acres of land	367,351,534
Value of land and buildings	$52,719,506,070
Months of labor	19,001,949
Value of capital	$21,599,070,055
Gross production	$10,274,959,333
Per farm:	
Acres of land	314
Value of land and buildings	$45,018
Months of labor	16.2
Value of capital	$18,444
Gross production	$8,774
Factor earnings	$3,009
Factor opportunity cost	$9,424
Observed land price per acre	144

REORGANIZATION OF FARMING TO APPROXIMATE THE MINIMUM COST CONDITIONS IN 1959

In the preceding chapter the resource and production characteristics of the farming industry as it existed in 1959 were identified. It was hypothesized that two types of resource imbalances were present:

a. larger quantities of factors of production were employed than were needed to produce the level of output,

b. aggregate farm output exceeded demand.

The present chapter is concerned with the reorganization of farming to correct the imbalance in resource cost; that is, to restructure farms to their minimum cost level of output. In this reorganization, industry level of output was not restricted.

At the minimum cost level of output farms would be organized so that average and marginal costs of production were equated with a given, fixed product price. Product price was held at the 1959 level in this step. This would mean that all costs of production, including factor opportunity costs, were just covered at that level of firm output.

For the aggregated North Central Region, per farm factor earnings were $3,009 and opportunity costs were $9,424 in the existing farm situation in 1959. This information was reported in Table 14 in the preceding chapter, and similar data for each of the 71 Census subregions were reported in the supplementary tables (22). Government price support and production restricting activities in 1959 were reported in a preceding chapter. Thus, the per farm factor opportunity costs exceeded factor earnings at prices higher than the market-clearing prices. Had markets been allowed to clear the discrepancy between them would have been even greater.

The procedure for reorganizing the farm industry to approximate the minimum cost of production conditions in 1959 was divided into three steps:

a. a number of farms that appeared to be well-organized were identified from farm business records,

b. these observed farm record data were adjusted to account for influences that distorted the measurement of resource productivity and a final group of farms selected on the basis of adjusted factor earnings being equated with opportunity costs,

c. the land base in each subregion was reorganized into minimum cost farms, based on the mean characteristics of the selected farms.

Identification of Well-Organized Farms

Three procedures for determining the characteristics of well-organized farms were considered:

a. production function analysis,

b. linear programming analysis,

c. identification and analyses of economically efficient farms.

Production function analysis

Production function analyses of farm business data was not without precedent. Ezekiel and Fox cited application of multiple correlation techniques to farm survey data in Pennsylvania and Virginia in 1925 and 1926 (21, p. 443).

Production function analyses based on data contained in Iowa farm business records for 1939 were made by Tintner and Brownlee (19). They fit a linear in logarithms multi-variable function of the Cobb-Douglas type to individual farm record data. Some negative elasticities were in the solutions and a farm with increasing returns to scale was observed but generally the results were reasonable. The authors indicated that the main value of the study was methodological.

An identical study based on the mean characteristics of a sample of Iowa farms was reported by Heady (20). He indicated that problems were encountered in combining complementary inputs into single variables, in the complete identification and measurement of variables, and the application of inter-farm functions to individual farm units. Inter-area comparisons of factor productivities were more meaningful than inter-factor comparisons within a geographic area, according to the author.

Production function analyses of farm record data hold true only for the year of the data due to fluctuations in prices and yields. Functions based on the mean characteristics of a group of farms do not necessarily indicate the optimal organization for any one farm in the group (21, p. 443).

Additional problems arise in the meaningful categorization of inputs into independent variables, complete and accurate measurement of inputs and output and in the lack of homogeneity among farms in factor quality.

A production function fit to relevant variables based on data which accurately reflects the observed farm production relationships could be made to specify the resource and production characteristics of the farm industry with mathematical precision. However, the estimated characteristics might vary substantially depending upon which function was selected of those that might fit the observations reasonably well.

Linear programming

Linear programming is another tool basically well suited for determining the income maximizing organization of farms. It is useful, however, only as a vehicle for realistically defined restrictions and activities and for coefficients that accurately reflect farm production relationships.

Farm organization that would maximize income has been a frequently used objective in the numerous linear programming studies conducted since 1950 throughout the world.

A variable price programming model to develop supply functions for well-organized farms would have been usable in the present study to specify the minimum cost farm organization for every level of industry output. To be meaningful, however, the model would have required the determination of coefficients for so large a number of activities and restrictions that it was far beyond the resources available. For this reason linear programming was not used.

Identification and analysis of efficient farms

It was hypothesized that there were farm operators throughout the North Central Region in the base period who had developed their observation and decision-making abilities to the degree that the organization of their farm businesses approximately met the criteria for firm efficiency. These farms would be organized in a manner that would approximately meet the factor-factor, factor-product, and product-product requirements for an efficiently organized firm under the price and technological conditions existing.

In support of the hypothesis that there existed efficiently organized farms was the identification and intensive study of 16 such farms in an Iowa study (6). Additional support was provided by numerous annual farm business record summaries in which some farms or groups of farms had factor earnings that covered factor opportunity costs (3, 4).

Under theoretical conditions, production function analysis, linear programming, and the analysis of efficient farms would have yielded the same solutions. The analysis of efficient farms had a key operational advantage since it required less data for a valid analysis. However, it required the development of a rigorous criterion for the selection of efficiently organized farms. The criterion used was to select those farms that enjoyed the largest positive (or smallest negative) excess of factor earnings over factor opportunity costs.

Additionally, since not all farms were examined, an effective screening process for selecting the most likely farms for rigorous examination was needed.

Two procedures for identifying the efficiently organized farms were considered. In the southern Iowa pilot study that preceded the present effort, Census economic classes of farms were compared and the class with the least deficit between factor earnings and factor opportunity costs selected (12). The mean characteristics of that class of farms were considered to approximate those of efficiently organized farm firms.

Census data had the advantage of being uniform and complete for the variables reported for all the subregions in the North Central Region. However, they did not contain all the required information and were supplemented with farm business record data in the pilot study. Supplementary data from farm records or other sources would have been needed had this procedure been followed.

Since all farms were included in the Census enumeration process, use of that data had the advantage of certainty that the efficient farms were somewhere included. However, the reporting of Census data as the mean characteristics for groups of farms tended to obscure individual farm differences.

Farmers that participated in farm business associations were generally above average in management ability, size of farm business, and also net farm income. However, this did not necessarily mean that the farms that best approximated the firm efficiency conditions were included. Use of farm records had the advantage in allowing the comparison and selection of individual farms, not just groups of farms, however.

Individual farm records were available in sufficiently large numbers with generally good geographic and type of farming distribution to make this approach feasible. After considering the merits of each of the above general procedures for determining the characteristics of well-organized farms, it was decided to use the analyses of efficient farms identified from farm business records.

Farm business records

Farm business records were made available through the cooperation of the agricultural economics department of the land-grant university in each state in the North Central Region. Records had been kept by farm operators in cooperation with the extension service, experiment station, farm business association, or vocational agriculture departments. Copies of the farm record summaries for individual farms were made available from each of the cooperating states in the form of individual farm worksheets, summary worksheets, or computer punch cards.

Farm records for 1959 were preferred to insure comparability, but the particular year for which the farm records were available was not critical. The individual farm record data were adjusted for abnormal weather and deviations from cyclical mean hog and beef prices so that they would be comparable to the observed 1959 situation. This allowed flexibility in selecting years in which relatively large numbers of records were available in readily usable form.

The year for which records were used and the number of records available were reported in Table 15.

The farm business record data from south central Missouri were supplemented with results from a study exploring alternative enterprises and methods of production (69). Data were not available for two subregions in eastern Kentucky and they were not included in the study. Usable farm business records were available for 71 of the 73 subregions in the North Central Region.

Table 16. Numbers of farm records available and year used, by states

State	Year used	Number of farm records available
Ohio	1963	244
Indiana	1963	565
Illinois	1962	5,740
Michigan	1959	812
Wisconsin	1960	713
Minnesota	1962	745
Iowa	1962	1,200
Missouri	1959 and 1962	240
North Dakota	1962	134
South Dakota	1959	40
Nebraska	1962	137
Kansas	1959	1,071
Kentucky	1962	152
Total		11,793

In all cases the items reported in farm business record summaries gave the resource and production characteristics of individual farms in great enough detail to be adequate for the purposes of the present study.

Although the basic data selected from farms were similar in each state and all summaries were concerned with measures of size of business, efficiency and factor earnings, there was little uniformity among states in terminology and reporting procedures.

The farm records that were selected for use in the study were believed to reliably reflect the resource and production characteristics of the farms for which they were kept.

When data were available on punch cards the necessary data adjustments were made on the observed data for all the farms. In other cases, farm records were examined and the farms that apparently could not generate adjusted factor earnings equal to adjusted factor opportunity costs were not used. Data adjustments and final selection of farms are discussed in the following section.

Selection of Farms with Minimum Cost Organization

It was hypothesized that there were farms in each of the subregions in the North Central Region in 1959 whose resource and production characteristics were not significantly different from those of a firm meeting the criteria for firm efficiency. Given prices, costs, and production technologies these farms were organized in the manner that would meet the marginal conditions for firm efficiency. Farm business records of farmers were examined and farms that appeared likely to have factor earnings equal to factor opportunity cost were picked for further study. This procedure was described in the preceding section.

Preliminary sorting of farm records

Farmers that participated in farm business record associations were generally above average in management ability, size of farm business, and net farm income (70). By using records of participants in farm business associations, the selection process was begun prior to the present attempt to identify well-organized farms. Additionally, farms with low levels of factor earnings, atypical farms, and farms obviously not providing full-time employment opportunities for the operator were sorted out in the preliminary examination.

The observed data for the remaining farms were adjusted in several ways to make the farm data more validly comparable with the observed farm industry characteristics in 1959.

Adjustments of observed farm record data

Crop yields and value of production for all major crops were adjusted to account for abnormal weather. Weather indexes were used as described in the chapter concerning the observed situation in 1959.

The prices of hogs and beef cattle were adjusted to their cyclical means as described in an earlier chapter. This affected the value of sales, purchases, and inventory changes of these two classes of livestock. The estimations of appropriate opportunity cost rates for land, capital, and labor were described in an earlier chapter. Adjusted gross production, adjusted factor earnings, and factor earnings minus factor opportunity costs were calculated for each farm.

Selection of farms

Farms were arrayed in descending order on the basis of the residual when factor opportunity costs were subtracted from factor earnings. Farms with the largest positive residual were placed at the top of the array. There were farms in every subregion that had factor earnings greater than factor opportunity costs at 1959 prices. Had the price level been lower, fewer farms would have been in that situation. Thus, the array of farms was related to product prices.

The top farms in the array were selected to represent well-organized farms, the cutoff being the farm at which the accumulated sum of all factor earnings equaled the accumulated sum of the factor opportunity costs for all farms included in the array down to that point.

As a group, these selected farmers had factor earnings equal to factor opportunity costs. There would have been no incentive for resources to either enter or leave the industry under the structure of these farms. A group of farms was selected from farm business records using the above procedure in 70 subregions. Farm record data supplemented with results from a budgeting study were used in one additional subregion.

The above selection procedure indicated that there existed in 1959 farms whose factor earnings were as great or greater when employed in the farming industry as they would have been if employed elsewhere, under the 1959 production technologies, prices, costs, normal weather, and cyclically mean hog and beef cattle prices. Additionally, factor returns were higher on these farms than on the observed farms, since mean factor earnings were less than mean opportunity costs in each subregion under the observed 1959 conditions. This latter point was evidence that an imbalance in resource cost was widespread throughout the farm industry in the North Central Region in 1959.

The mean production and resource characteristics of the selected farms were used as the characteristics of well-organized farms with minimum-cost firm organization in 1959. The following section discusses the reorganization of the land base in each subregion into farms having these mean characteristics.

Reorganization of the Subregions into Minimum-Cost Farms in 1959

The mean resource and production characteristics of well-organized farms were identified in each subregion using procedures described in the preceding sections. These mean characteristics were used as the basis for the reorganization of the farm industry into minimum cost farms in 1959. The per farm characteristics which were estimated as the mean values for the selected well organized farms were:

a. gross production

b. capital input

c. man-months of labor

d. value of land input

e. factor earnings

f. opportunity cost of each factor

Deviations from the ideal model

An ideal model for estimating and projecting values for the unknowns in the problem was discussed in an earlier chapter. In that model, the firm production function was considered to be known and was used to determine the quantity of output and demand for each factor by the firm. Product prices were determined by relating industry production to total demand and land prices were determined by relating industry demand to the supply.

In the ideal model, internal consistency of the firm and industry organization could be ascertained by meeting the marginal conditions for economic efficiency as outlined in the same chapter.

The operational approach used in the reorganization of the subregion into minimum cost farms in 1959 deviated from the ideal model in one major point. Mean characteristics of farms whose factor earnings as a group equaled factor opportunity costs were used instead of the production function to estimate quantity of output and factor demand by the firm. Thus, the assumption that efficient farms existed and had been identified substituted for meeting the conditions for economic efficiency in the firm by determining that the marginal conditions were satisfied through production function analyses.

An additional deviation of lesser importance in this stage was the use of the observed product prices and land prices as given.

Estimating the number of farms

The land base in each subregion was a fixed resource in 1959. The labor and capital inputs in a subregion were relatively mobile and assumed to be free to move out of the farming industry in response to differentials between their farm earnings and nonfarm opportunity costs. The fixed quantity of land in a subregion was divided by the mean quantity of land per well organized farm to estimate the number of farms.

The subregion totals for value of capital input, man-months of labor, and gross production were calculated by multiplying the number of farms per subregion times the mean value per farm for these characteristics. The total volume of production by the industry was not restricted during this step.

The rationale for the minimum-cost reorganization hinges on the farm-nonfarm returns and opportunity costs of factors and their mobility. The nonfarm demand for farm land is price inelastic and once filled the opportunity cost of farm land to the farming industry approaches zero. Farm land would be used for farming purposes as long as the marginal return to land is greater than zero. The land base in the subregions was not changed during the first reorganization.

Labor and capital inputs, however, have opportunity costs to the farming industry equal to their returns in nonfarm employment. In the observed 1959 farming industry, factor earnings were less than factor opportunity costs. Thus, pressure was generated for the more mobile labor and capital to move from farming to nonfarm industries. It was assumed that this was accomplished by farm operators taking their labor and capital resources from farming and employing them where returns were equated with opportunity costs. The area of land vacated by a farm operator would be occupied by the remaining farm operators, increasing the per farm land base. The freed labor and capital resources would be employed wherever returns equaled opportunity costs.

The estimating procedure

The mean characteristics of well-organized farms were used as known variables in reorganizing the subregions into minimum cost of production farms. The computations for reorganizing the subregions were made by the Iowa State University Computation Center using an IBM 7074 computer. The market-clearing reorganizations for 1959 and 1980 were also computed in this manner.

Known variables for 1959 used in the minimum cost reorganization and the market-clearing reorganization for 1959 were:

X_1 = acres in commercial farms in the subregion

X_2 = value of farm real estate in commercial farms in the subregion

X_3 = opportunity cost rate for land

X_4 = opportunity cost rate for capital

X_5 = mean land value per well-organized farm

X_6 = mean man-months of labor per well-organized farm

X_7 = mean capital input per well-organized farm

X_8 = gross production per well-organized farm

X_9 = factor earnings per well-organized farm

X_{10}= total opportunity cost of factors per well-organized farm

A series of nine equations were solved using the above variables to specify the characteristics of the farm industry after the minimum cost reorganization in 1959. The equations represented a simplified approximation of the relevant relationships believed to exist in the farming industry. The series of equations were solved independently for each subregion.

The number of commercial farms per subregion was determined by dividing the value of farm real estate in the subregion by the mean value of land per well-organized farm. This was designated as Y_1:

$$Y_1 = \frac{(X_2)}{(X_5)}$$

The total man-months of labor employed in the subregion was calculated by multiplying the number of farms times the mean man-months per well-organized farm. This variable was Y_2:

$$Y_2 = (Y_1)\ (X_6)$$

The total capital employed in the subregion was calculated by multiplying the number of farms times the mean capital input per well-organized farm. This variable was Y_3:

$$Y_3 = (Y_1)\ (X_7)$$

The total gross production produced by farms in the subregion was determined by multiplying the number of farms times the mean gross production per well-organized farm. This variable was Y_4:

$$Y_4 = (Y_1)\ (X_8)$$

The mean acres per farm was calculated by dividing the total acres in the subregion by the number of farms and was identified as Y_5:

$$Y_5 = \frac{(X_1)}{(Y_1)}$$

The opportunity cost of the land used per farm was calculated by multiplying the opportunity cost rate for land times the mean value of land per well-organized farm. This variable was Y_6:

$$Y_6 = (X_3)\ (X_5)$$

The opportunity cost of capital used per farm was calculated by multiplying the opportunity cost rate for capital times the mean capital input per well-organized farm, and was identified as Y_7:

$$Y_7 = (X_4)\ (X_7)$$

The total opportunity cost of labor used per farm was calculated by subtracting the opportunity costs of capital and land from the total opportunity cost of factors per well-organized farm. This variable was Y_8:

$$Y_8 = (X_{10}) - (Y_7) - (Y_6)$$

The opportunity cost of labor and capital per farm were subtracted from factor earnings per farm. This residual, on a per acre basis, was capitalized into a land value per acre. This variable was Y_9:

$$Y_9 = \frac{(X_9) - (X_{10}) + (Y_6)}{(Y_5)\ (X_3)}$$

Empirical results

The resource and production characteristics of the farming industry were estimated for 1959 for each of the 71 subregions in the North Central Region. These results are presented in the supplementary tables (22). Aggregations of subregion data into interstate subregions are presented in a later chapter on results.

The aggregated estimates for the entire North Central Region are compared with the observed 1959 situation in Table 17.

The selected well-organized farms had a substantially larger land base than the observed farms in 1959. For the aggregated North Central Region, value of land and buildings per farm was 64 percent larger after the minimum cost reorganization than in the observed situation. With a fixed land base, this resulted in a reduction in the number of farms by 39 percent.

For the aggregated North Central Region, input of labor was reduced 21 percent while input of capital was increased 32 percent. An increase in gross production of 98 percent resulted. The total cost of factors declined from $11.04 billion to $10.94 billion while gross production increased from $10.27 billion to $20.39 billion. This suggested that an imbalance in resource cost existed in 1959.

Evidence of another type of imbalance was provided by the per farm characteristics. Per farm factor earnings equaled factor opportunity costs at the observed price level, the 1959 produce price level. However, aggregate production had increased some 98 percent over the observed 1959 production. Assuming that the North Central Region was

Table 17. Resource and production characteristics of farming in the North Central Region under the observed situation and minimum cost reorganization in 1959

	Observed 1959 situation	Minimum cost 1959 reorganization	Percent change
Subregion totals:			
Number of farms	1,171,089	714,464	- 39
Acres of land	367,351,534	367,351,534	0
Value land and buildings	$52,719,506,070	$52,719,506,070	0
Months of labor	19,001,949	14,948,946	- 21
Value of capital	$21,599,070,055	$28,570,988,416	+ 32
Gross production	$10,274,959,333	$20,389,023,495	+ 98
Per farm:			
Acres of land	314	515	+ 64
Value land and buildings	$45,018	$73,789	+ 64
Months of labor	16.2	20.8	+ 28
Value of capital	$18,444	$39,853	+116
Gross production	$8,774	$27,491	+213
Factor earnings	$3,009	$15,312	+409
Factor opportunity cost	$9,424	$15,312	+ 62
Observed land price 1959	$144		
Residual to land capitalized into a value per acre	< 0	$135	--

allocated some specific share of total demand for farm production, then had markets been allowed to clear, product prices would have been less than the observed 1959 product prices. The reorganization had added substantially to the observed excess production of farm products in 1959.

This would have reduced factor earnings per farm without reducing factor opportunity costs. A situation in which factor earnings by well-organized farms were less than factor opportunity costs would result.

This was accepted as evidence that an imbalance in level of farm production existed after the minimum cost reorganization i.e., there was an excessive quantity of resources committed to farming. A second reorganization to approximate the market-clearing conditions within the framework of well-organized farms was made, and is discussed in the following chapter.

REORGANIZATION OF MINIMUM COST FARMS TO APPROXIMATE THE MARKET-CLEARING CONDITIONS IN 1959

Need and Rationale for a Second Reorganization

In the preceding chapter the reorganization of the farm industry into minimum cost farms in 1959 was described. Among other changes, the first reorganization generated a 98 percent increase in aggregate output for the North Central Region. This quantity of production exceeded greatly the share of total demand that could be allocated to the North Central Region and would not have cleared markets at the 1959 price level.

Had this production been placed on the open market, product prices would have declined below the 1959 level and factor earnings would have dropped to some level less than equality with opportunity costs. The inequality between factor earnings in farming and their nonfarm opportunity costs would have generated the necessary pressure for the shifting of labor and capital from farm to nonfarm uses.

The rationale for shifting labor and capital from farming rather than land was explored in an earlier chapter. The argument hinged on the relative opportunity costs of the factors to the farm industry, which were about zero for farm land but equal to returns in nonfarm employment for labor and capital. In the situation following the first reorganization, factor earnings would have been less than factor opportunity costs and pressure would have been generated for labor and capital to seek their opportunity costs in nonfarm industry. Land would not have been removed from farming until its marginal returns dropped to a level equal to its opportunity cost to the farm industry. The demand for farm land by the nonfarm industry was relatively price inelastic, and once that relatively small demand was filled, the opportunity cost of land to the farming industry would approach zero.

<u>Extensification of the farm industry</u>

It was established in preceding sections that pressures were generated by the minimum cost reorganization for labor and capital to shift out of the farming industry. Had the farm production function outlined in the ideal model been known, the proportion and quantities of capital and labor leaving the farm industry and the capital, labor, and land mix on the remaining farms could have been calculated with precision. In the absence of knowledge about factor substitution rates it was necessary to deviate from the ideal model and make assumptions and judgments.

It was assumed that when a farm operator responded to the discrepancies between his factor earnings and their nonfarm opportunity costs he would shift the entire bundle of capital and labor associated with his farm business into nonfarm employment. He would remove his own labor input as well as any family labor input from farm production, he would cease to hire labor and he would convert his farm capital into nonfarm forms.

The substance of this assumption was that labor and capital would be removed from the farm industry in the same ratio as they appeared on well-organized farms and they would continue to be combined in that same ratio on the farms remaining.

It was further assumed that the quantities of capital and labor per well-organized farm would not be changed during the market-clearing reorganization. There would be incentive, however, for the remaining farmers to combine more land with their fixed labor and capital. Because of the decline in the number of farmers, the demand for land would be lessened and land price would decline, making it relatively low cost compared to the other factors. The remaining farmers would add the land freed to their farm businesses.

As additional land was added to the fixed input of labor and capital on the remaining farms the gross production per unit of land would decline, i.e. the marginal physical product of land would decline. Given the fixed land base in the North Central Region output would decline as labor and capital shifted into nonfarm employment. In the operational model used, labor and capital were removed until the total gross production in the subregion equaled the subregion share of total farm demand at the 1959 price levels. This resulted in an industry equilibrium with total supply equal to total demand at the 1959 price level.

The industry equilibrium was attained with the concomitant minimum cost organization of farms by an extensification procedure. The procedure was carried out by decreasing the input of capital and labor per unit of land within guide lines determined by the characteristics of the selected group of well-organized farms.

In each of the 71 subregions an extensification regression was developed using certain characteristics of the selected group of well-organized farms used as observations. The capital plus labor input per unit of land was regressed on gross production per unit of land as the dependent variable. The equation fitted was linear of the form

$$\hat{Y} = a + bX,$$

where $\hat{Y}$ equaled the estimated gross production per unit of land and X was the capital plus labor input per unit of land.

It was assumed that the observed price of land per acre in 1959 was a reasonable index of its relative productivity. Land measured in dollar terms would thus be a homogeneous factor. The unit of land used in the regression equations was one dollar's worth of land.

The capital plus labor input that was used measured the services of those two factors in the production process. It was estimated as the sum of the opportunity cost of labor, opportunity cost of capital, production expenses, and depreciation.

Given a subregion's share of farm product demand and the land base, the value of $\hat{Y}$ was calculated as the share of demand divided by the land base. The values for the a and b variables had been estimated in making the regression. The equation could then be solved for X, the input of the services of capital and labor per unit of land.

The product of X multiplied by the land base in the subregion yielded an estimate of the total capital plus labor services input for the subregion. Since the per farm capital plus labor services input was known, the number of farms in the subregion after the extensification procedure was determined through division.

Determination of other relevant variables followed. A detailed description of the estimating procedures used is contained in a later section of this chapter.

The extensification procedure described above was carried out with product prices at their 1959 level. This may or may not have been the equilibrium level. Extensification and product price decline is explored in a later section in this chapter, following a discussion of the limitations of the extensification procedure.

<u>Limitations of the extensification procedure</u>

The regression equation used in the 1959 market clearing reorganization facilitated the estimation of resource and production characteristics of minimum cost farms after the second reorganization. It was a means of identifying farms that were extensive in their organization.

<u>An alternative</u> An alternative approach would have been to examine the individual farm records of the selected group of well organized farms and pick those with relatively low capital and labor input and low gross output per unit of land. If several extensive farms were located their mean characteristics could have been used.

The regression equation had the advantage that the mean characteristics would be based on records of a larger number of farms.

<u>Extensification range</u> The regression equation had the additional advantage of providing an estimate of farm characteristics when extensification was carried beyond the range of experience of the selected group of well-organized farms. That is, the regression equation could

estimate the characteristics of farms organized at degrees of extensification not included among the observed farms. However, this was at the same time an additional problem since it provided a theoretical farm organization but introduced questions concerning the feasibility and realism of the organization.

Extensification was accomplished within or close to the range of experience in three-fourths of the 71 subregions. In seventeen subregions, however, gross production per unit of land was noticeably less than the most extensive observed farm. These subregions were widely scattered but were mainly in the central and eastern areas of the North Central Region.

There were two major implications of this development. None of the 17 subregions were in major Great Plains wheat or ranching areas but rather in more intensive crop and livestock producing areas. This suggested that for extensification to proceed as indicated, changes in farm product mix to crop and livestock enterprises not commonly used might have to take place. That is, alternatives in cropping systems might include such relatively extensive crops as wheat and small grains instead of corn and soybeans. Livestock alternatives might shift to cattle ranching from the relatively more intensive hog raising, dairying, and cattle feeding. Thus, the extensification might be accomplished through changes in product mix.

A second implication was that there might be a need for new production techniques that made commonly used enterprises relatively more extensive. This was the less promising of the two alternatives for the extensification of the farming industry.

Fitting the regression equation It was indicated previously that the data contained in the individual farm record summaries were believed to accurately reflect the nature of the farm business in most cases. Data from states that provided relatively thorough professional supervision of farm record keeping and record analysis generally had good fits in making the regression equation. In some other cases, however, meaningful relationships among the farms were not so readily apparent. In those cases the regression equation for a similar adjacent subregion was used, or data from farms in adjacent similar subregions were combined to develop the regression.

In general, the extensification regression was fit satisfactorily to observed farm data.

Relation to the production function The extensification equation could have been considered as representing a linear segment of the production surface where used within the range of observations. The quantity of farm output was dependent upon inputs of land and a capital plus labor combination, which were reasonable variables for explaining farm production.

The production function was used as a guide in the extensification procedure but because of lack of control over input measurement was not considered reliable for additional analysis. That is, the data upon which the production function was built were not considered to be adequate for unqualified acceptance of the fitted function as representative of the existing physical relationships. For this reason, firm demand schedules for factors or firm supply schedules of products were not developed from the production functions.

The suggestion that the relevant segment production surface seemed linear in the 1959 analysis was the basis for later assumptions about the marginal physical productivity of land in 1980. The assumption is examined and discussed in a later chapter.

<u>Extensification and product price decline</u>

The extensification of the farm industry under 1959 product prices was described earlier in the present chapter. It was indicated that the 1959 price was not necessarily the equilibrium price level. Extensification combined with product price decline is discussed in the following section.

As a simplified hypothetical example, Figure 1 illustrates farm production and demand for a geographic area under three sets of circumstances. In each part of the diagram, D represents the demand for farm products and Q_3 represents the quantity demanded at the 1959 price level.

<u>The observed 1959 situation</u> In Figure 1A, S_1 represents the farm products supply schedule and Q_1 the quantity supplied in the observed situation at P_{59} the 1959 price level. Q_1 is greater than Q_3, indicating excess production. Elsewhere in the present study, excess production in the United States in 1959 was estimated to be about 6 percent.

<u>Minimum cost reorganization</u> S_2 in Figure 1A and subsequent figures represents the farm products supply schedule and Q_2 the quantity

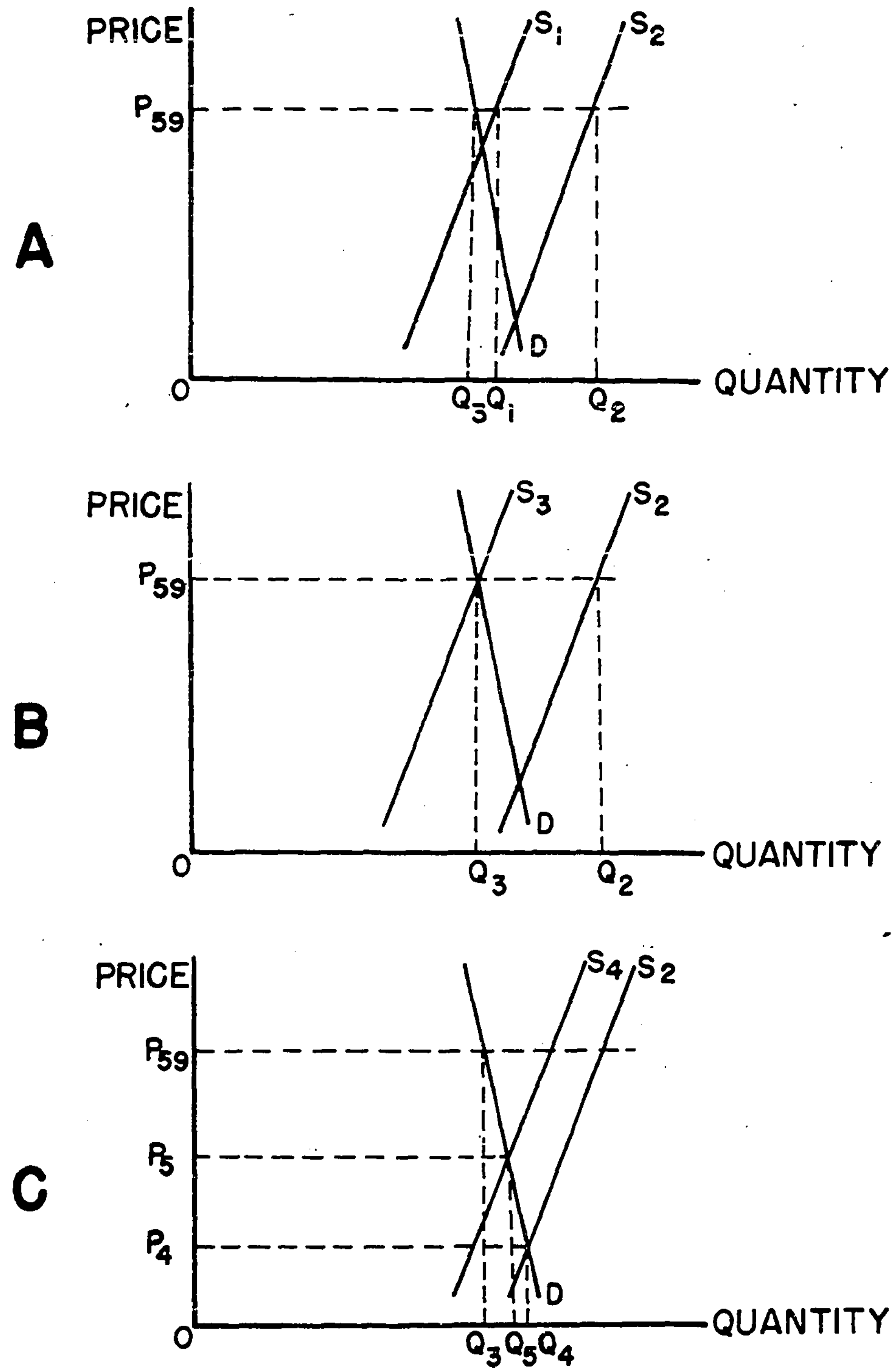

Figure 1. Farm production and product demand illustrating extensification and price adjustments

supplied after the minimum cost reorganization in 1959. It should be noted that in the minimum cost reorganization the total quantity of production was not restricted. Thus, the supply schedule S_2 has shifted to the right relative to S_1. Q_2 is larger than Q_3 or Q_1 and was estimated to be 98 percent greater than Q_1, the observed quantity of production in 1959, in the North Central Region. The difference between Q_3, the quantity demanded at the 1959 price level, and Q_2 measures the excess production after the minimum cost reorganization in 1959.

Extensification at 1959 prices In Figure 1B extensification has taken place at the 1959 price level. The supply schedule was shifted to the left and S_3 represents the farm product supply schedule of the extensified farms. Extensification was pursued until the quantity produced, Q_3, was equal to the quantity demanded at the 1959 price level. However, the 1959 price level, P_{59}, was not necessarily the equilibrium price level.

Extensification and product price decline Excess production was eliminated in Figure 1B by shifting the supply schedule through extensification. In Figure 1C excess production had been eliminated by allowing product prices to drop to the P_4 level. At that price, Q_4 is both the quantity demanded and produced and there would be no excess production.

The end points in the range of alternatives for eliminating excess production were thus defined. At Q_4, product price decline accounted for the elimination of excess production. At Q_3, extensification had eliminated excess production.

S_4 represents one of the infinite number of combinations of extensification with product price decline. The decrease in production represented by the difference between S_2 and S_4 was accomplished by extensification, and the price decline from P_{59} and P_5 increased the quantity demanded sufficiently for the remainder of the quantity produced to be demanded. The problem generated here was which combination of extensification and product price decline represented the equilibrium situation.

Estimating the equilibrium price level During the extensification process additional land was combined with the fixed capital and labor inputs on the farms that remained in operation. This reduced the marginal physical product of land. For the farm industry, labor and capital inputs were decreased and the land base remained fixed, which was consistent in causing a reduction in the marginal physical product of land.

The decline in marginal physical productivity of land with either constant or decreasing product prices would result in a lower marginal value product and price of land. A lower price for land would be reflected in lower cost of production and under the relatively competitive structure of the farm industry in a lower price of product. Thus, it appeared that the equilibrium price level would be at some level less than the 1959 price level.

The lower limit on equilibrium product price level was estimated by determining the price levels at which the capitalized residual value of land was driven to zero. As explained elsewhere, the latter variable was the per acre residual when opportunity costs of labor and capital were subtracted from factor earnings, the residual being capitalized into a land value.

Subregions varied in the product price at which their residual to land was driven to zero. Generally, areas with less productive land, i.e., with a lower observed land price in 1959, were affected first. Northern Minnesota, Wisconsin, and Michigan, south central and southwest Missouri, and southeast Kansas were the first subregions to be affected as product price was lowered in successive iterations.

Negative land values would have been inconsistent with economic efficiency criteria. Land value at the equilibrium would be equated with its capitalized marginal value product. If the latter were negative at positive product prices, negative marginal physical productivity of land would be implied. The latter would be inconsistent with rational combination of factors.

The lower limit to which product price could be lowered appeared to be at about 95 percent of the 1959 price level. At this price, negative land values would have begun to appear in some subregions.

The marginal value product of land was calculated from the regression equation and equated with the capitalized residual to land in several subregions where the farm record data were believed to be exceptionally reliable. In general, they were equated at product prices that were between 95% and 100% of the 1959 product price level. While this was not conclusive, it added support to the hypothesis that the appropriate range in product prices had been determined.

A discrete estimate of equilibrium product price was needed so that the resource and production characteristics of the farm industry could be stated as single values. A range of values would not have been completely satisfactory since the characteristics were used later as inputs in the 1980 projections.

The midpoint in the range, 97 percent of the 1959 price level, was selected as a discrete estimate of equilibrium product prices. The characteristics of the farm industry after the 1959 market-clearing reorganization were reported for that price level. Values for the characteristics, however, were relatively insensitive to product prices in that price range, and which particular price was used was not a critical assumption.

The Estimating Procedures

A series of equations were developed to systematically determine the endogenous variables in the market-clearing reorganization. Several variables were considered to be known in the market-clearing reorganization, including the 10 exogenous variables identified as X_1, X_2, . . ., X_{10} in the minimum cost reorganization. Three additional exogenous variables were used:

X_{11} = a-value in the regression equation.

X_{12} = b-value in the regression equation.

X_{13} = quantity of production demanded from commercial farms in the subregion at 1959 product price level.

The nine endogenous variables which were estimated in the minimum cost reorganization, identified as Y_1, Y_2, . . ., Y_9, were considered to be known values for the market-clearing reorganization. Three additional Y variables were estimated and used as known values.

Farm operating expense plus depreciation were identified as capital consumed in the production process on the well-organized farms. This variable was identified as Y_{10} and was estimated as gross production minus factor earnings:

$$Y_{10} = (X_8) - (X_9)$$

Gross production per unit of land in the industry equilibrium situation was designated as Y_{11}. This was the value of $\hat{Y}$ in the extensification equation and was estimated by dividing the subregion share of demand at 1959 product prices by the land input per subregion:

$$Y_{11} = \frac{(X_{13})}{(X_2)}$$

The X variable in the extensification equation, capital plus labor services per unit of land, was identified as Y_{12}. It was estimated by inserting the values for $\hat{Y}$, a, and b into the regression equation and solving for X:

$$Y_{12} = \frac{(Y_{11}) - (X_{11})}{(X_{12})}$$

It was indicated in preceding sections of this chapter that total farm production could be equated with demand through extensification, product price decline, or some combination of the two. Since no criterion was available to a priori specify the industry equilibrium output and product price, a range of equilibrium prices was estimated with a high probability that they encompassed the true value. The midpoint of that range was assumed to be the equilibrium product price.

It was necessary, however, to first calculate the industry production and resource characteristics for a series of product price-extensification combinations in order to identify that possible range of equilibrium prices. Estimates were calculated for the 1959 product price level, i.e., extensification with no price drop, and several other combinations with a product price drop and extensification. These solutions were examined to estimate the equilibrium price level, as described in a preceding section.

Independent estimates were calculated for each of the 71 subregions for each selected price level. The series of equations that were used are described in the following. Values for each of the Z variables were calculated for a given price level; the price level was then lowered and another set of solutions estimated in an iterative procedure.

The superscript i on the Z variable identifies the price level. The $i = 1, 2, \ldots, n$, where n equals the number of product price-extensification combinations examined.

The subregion share of farm product demand at the 1959 price level and the price elasticity of demand for farm products were used to estimate the share of demand at a series of product price levels. The subregion share of demand at the i-th price level was identified as Z_1^i.

The physical quantity demanded was multiplied by 1959 prices as a common numeraire for comparisons. The equation used was:

$$Z_1^{\,i} = (1.23 - .23\,P_i)\,(X_{13})$$

Gross production per dollar of land was calculated by dividing the quantity of farm production by the value of farm real estate in the subregion. This variable was $Z_2^{\,i}$:

$$Z_2^{\,i} = \frac{Z_1^{\,i}}{X_2}$$

The regression equation was of the form Y = a + b X, with X the input of capital and labor per dollar of farm land. It was identified as $Z_3^{\,i}$, and was calculated by solving the regression equation for the X variable:

$$Z_3^{\,i} = \frac{(Z_2^{\,i}) - (X_{11})}{(X_{12})}$$

The number of farms in the subregion was calculated by first determining the total input of capital and labor in the subregion. Multiplying the input of capital and labor per dollar of farm land times the total value of farm land in the subregion gave this value. The total capital and labor input in the subregion was divided by the input of capital and labor per farm in the first reorganization to determine the number of farms in the subregion. This variable is identified as $Z_4^{\,i}$:

$$Z_4^{\,i} = \frac{(Z_3^{\,i})(X_2)}{(Y_8) + (Y_7) + (Y_{10})}$$

The total man-months of labor used in the subregion after the second reorganization was determined by multiplying the number of farms in the subregion by the man-months of labor per farm as estimated in the first reorganization. This variable was Z_5^i:

$$Z_5^i = (Z_4^i)(X_6)$$

The total capital input in the subregion was estimated by multiplying the number of farms in the subregion by the capital input per farm after the first reorganization. This variable was called Z_6^i:

$$Z_6^i = (Z_4^i)(X_7)$$

The acres per farm after the second reorganization was determined by dividing the total acres in commercial farms in the subregion in 1959 by the number of farms after the second reorganization. This variable was Z_7^i:

$$Z_7^i = \frac{(X_1)}{(Z_4^i)}$$

The value of land and buildings per farm after the second reorganization was calculated by dividing the total value of farm real estate in the subregion in 1959 by the number of farms in the subregion after the second reorganization. This variable was Z_8^i:

$$Z_8^i = \frac{(X_2)}{(Z_4^i)}$$

The total revenue per farm was equal to the physical units of production produced per farm multiplied by the price level at which aggregate production would have cleared the market.

$$Z_9{}^i = \frac{(Z_1{}^i)(P_i)}{(Z_4{}^i)}$$

Factor earnings per farm after the second reorganization were calculated by subtracting the operating expenses and depreciation from the total revenue, as calculated in the preceding equation. This variable was identified as $Z_{10}{}^i$:

$$Z_{10}{}^i = (Z_9{}^i) - (Y_{10})$$

The opportunity cost of land per farm after the second reorganization was calculated by multiplying the value of land and buildings per farm times the opportunity cost rate for land. This variable was $Z_{11}{}^i$:

$$Z_{11}{}^i = (Z_8{}^i)(X_3)$$

Total factor opportunity costs per farm after the second reorganization was determined by summing the opportunity cost of land per farm with labor and capital opportunity costs per farm after the first reorganization. This variable was identified as $Z_{12}{}^i$.

$$Z_{12}{}^i = (Z_{11}{}^i) + (Y_8) + (Y_7)$$

The residual to land was calculated by subtracting the opportunity cost of labor and capital from factor earnings and dividing by the number of acres per farm to get the land residual on a per acré basis. This residual was capitalized into a value of land per acre by dividing it by the opportunity cost rate of land. The variable was identified as $Z_{13}{}^i$.

$$Z_{13}{}^i = \frac{(Z_{10}{}^i) - (Z_{12}{}^i) + (Z_{11}{}^i)}{(Z_7{}^i)(X_3)}$$

Empirical Results

The characteristics of the farming industry after the market-clearing reorganization in 1959 were estimated for each of the 71 subregions in the North Central Region. Those results are presented in the supplementary tables (22) and are presented in the chapter on results for the interstate subregions.

The aggregated estimates for the North Central Region are presented in Table 18, with comparisons with the observed situation and minimum cost reorganization.

About one-fourth of the number of farms in the region in 1959 remained after the minimum cost and market clearing reorganizations. Their characteristics were markedly different, also. Acres per farm increased from 314 to 1,200 acres, labor per farm was up from about 16 months to about 21 months, and value of capital increased from $18,000 to about $40,000.

Output per farm increased from about $9,000 to about $30,000.

For the entire North Central Region, the land base was unchanged. Man-months of labor declined by about two-thirds and capital input by about 45 percent. Total production decreased 11 percent to bring the aggregate production into line with the evaluated share of demand for the region.

Land value was estimated to be just under $100 per acre, compared to $144 in the observed situation in 1959.

The combined value of investment in land and capital per farm increased from \$63,462 in the observed 1959 situation to \$212,036 after the minimum cost and market clearing reorganizations in 1959.

Table 18. Resource and production characteristics of farming in the North Central Region under the observed situation, minimum cost, and market-clearing reorganizations in 1959, with comparisons

	Observed 1959 situation	Minimum cost reorganization 1959	Percent change from 1959 observed situation	Market-clearing reorganization 1959	Percent change from 1959 observed situation
Subregion totals:					
Number of farms	1,171,089	714,464	- 39	306,183	- 74
Acres of land	367,351,534	367,351,534	0	367,351,534	0
Value land and buildings	$52,719,506,070	$52,719,506,070	0	$52,719,506,070	0
Months of labor	19,001,949	14,948,946	- 21	6,420,445	- 66
Value of capital	$21,599,070,055	$28,570,988,416	+ 32	$12,182,576,651	- 44
Gross production	$10,274,959,333	$20,389,023,495	+ 98	$9,141,275,421	- 11
Per farm:					
Acres of land	314	515	+ 64	1,200	+282
Value land and buildings	$45,018	$73,789	+ 64	$172,183	+282
Months of labor	16.2	20.8	+ 28	20.8	+ 28
Value of capital	$18,444	$39,853	+116	$39,853	+116
Gross production	$8,774	$27,491	+213	$29,856	+240
Factor earnings	$3,009	$15,312	+409	$17,812	+492
Factor opportunity cost	$9,424	$15,312	+ 62	$17,812	+ 89
Observed land price 1959	$144	--	--	--	--
Residual to land capitalized into a value per acre	< 0	$135	--	$97	--

REORGANIZATION OF FARMING TO APPROXIMATE THE MINIMUM COST AND MARKET-CLEARING CONDITIONS IN 1980

The procedures used in estimating the minimum cost and market-clearing situations for the farm industry in 1959 were described in preceding chapters. The same general procedures were used for making the projections for 1980. However, data which were observed phenomena in the 1959 model had to be projected for use in 1980.

The present chapter is divided into four broad topics concerning the 1980 farm industry and its reorganization:

a. Projected demand for farm products,

b. Projected land supply and factor prices,

c. Projected resource combination on farms, and

d. Projected market-clearing industry organization.

Projected Demand for Farm Products

The estimated market-clearing quantity of farm production demanded at the 1959 price level was determined by estimating directly the utilization of farm production at observed prices in 1959. The estimated and projected demands for farm production in 1959 and in 1980 were allocated among the subregions on the basis of a time-series regression of each subregion's percentage share of total United States farm production.

The projection of the 1980 total demand was based on the 1959 market-clearing quantity using estimated changes in population, income per person, and export demand as demand shifters. Total 1980 demand was allocated among subregions as indicated above.

Domestic utilization in 1959

Data concerning domestic utilization were available (71, 72) but estimates of exports at 1959 prices were difficult to obtain because of the complex nature of government export subsidies and programs (10, 11).

Total net domestic utilization for food and nonfood uses in 1959 was reported as $29,927,000,000 in 1947-49 farm prices (71). Converted to 1959 farm prices, net domestic utilization was estimated to be $26,503,351,200.

Exports of farm production in 1959

United States exports of farm production in 1959 dollars was estimated using two major data sources. Exports under specified government-financed programs and exports outside specified government-financed programs, but including some government subsidization, were reported for calendar year 1959 (10). Disposition of Commodity Credit Corporation price-support program commodities as exports was reported by fiscal years (11). The reported CCC dispositions through exports were used in estimating level of exports under various government programs. Total agricultural exports estimated in this manner are reported in Table 19.

The total value of agricultural exports was included in the USDA supply-utilization series from which the estimate of domestic utilization was taken, but no allocation was made among government programs and commercial transactions (71, 72). The total reported in the USDA supply-utilization series, however, was similar to the summed total of all agricultural exports in Table 19. It was assumed that the data were comparable and that domestic utilization reported in the USDA supply-utilization series could be combined with the itemized estimates of exports to represent the total demand for United States agricultural production in 1959.

Exports as a component of demand in 1959

Takings of farm products that originated from domestic utilization and unassisted commercial export transactions were components of demand at observed market prices in 1959. However, government-assisted exports and exports under government programs could not be considered in their entirety to be parts of the market-clearing demand.

In the present study, government export activities were classified into two categories on the basis of objectives. One objective of government export activity was the reduction of surplus agricultural commodities from storage and markets in the United States. A second objective was to further nonagricultural goals of the government, such as developing good will, promoting economic growth and political stability in developing countries, developing stock-piles of strategic materials, and humanitarian goals.

Where the second objective seemed to be clearly the case, the takings of the government were considered to be a component of demand. That is, the government agencies exporting farm production for objectives other than surplus disposal were considered to be demanders of farm production,

Table 19. United States exports under specified government-financed programs, and estimated export component of total demand for United States farm production, 1959, (in 1959 dollars)

Government program or conditions for exporting	Observed values of exports in calendar year 1959[a]	Estimated component of total demand for United States farm production[b]
Public Law 480:		
Title I, sales for foreign currency	$ 732,000,000	$ 183,000,000
Title II, disaster relief (value stated as CCC cost)	56,000,000	38,976,000
Title III, donations (value stated as export value)	107,000,000	107,000,000
Title III, barter for strategic materials and overseas services	176,000,000	176,000,000
Mutual Security (AID), Sections 402 and 550, sales for foreign currency and economic aid (value shown is the disbursements for exports)	158,000,000	39,500,000
Total exports outside specified government-financed programs (sales for dollars) including unassisted commercial transactions and shipments of some commodities with government assistance in the form of the following:		
(a) Extension of credit for relatively short periods	30,000,000	30,000,000
(b) Sales of Government owned commodities at less than domestic market prices	123,300,000	30,825,000
(c) Export payments in cash or in kind	101,100,000	25,275,000
Unassisted commercial transactions	2,471,600,000	2,471,600,000
Total agricultural exports, 1959	$3,955,000,000	
Total estimated component of total demand for United States farm production, 1959		$3,102,176,000

[a]Source: (71, 72).

[b]The estimation of these values was discussed in the text.

comparable to domestic demanders and commercial, non-subsidized exporters.

In Table 19, the donations and barter for strategic materials and overseas services under Title III of P.L. 480 were considered to be in this category and their observed values were included at 1959 prices.

Disaster relief under Title II of P.L. 480 was also considered to be in this category but was not included at the observed value since that represented CCC costs, not market price. It was assumed that the quantity of commodities involved could have been obtained at market price and that the ratio of "CCC sales proceeds value" to "CCC cost value" in fiscal 1959 and fiscal 1960 could be used to estimate approximately the market value of the Title III donations in 1959. The value of this ratio was .696. Thus, $38,976,000 was considered to be a component of export demand out of the total observed $56,000,000 when valued at "CCC cost value".

Additionally, exports made with credit extended by the government for short periods of time were considered to be entirely a component of demand, implying there would have been no significant change in this value if non-government sources of credit had been used.

The four remaining categories in Table 19 were considered to be mainly devices for removing surplus agricultural production from United States storage and markets while concomitantly meeting other nonagricultural objectives. Among the remaining categories were sales of government owned commodities at less than domestic market price. These were valued at $123,300,000 at market price. Also included were export subsidy payments in cash or kind totaling $101,100,000 at market prices. Additionally, there were sales for foreign currency under Title I of

P.L. 480 valued at $732,000,000 and sales for foreign currency and economic aid under Mutual Security (AID), Sections 402 and 550, which totaled $158,000,000.

The part of these exports which represented the extent to which they were used to meet nonagricultural objectives of the government were components of demand in the same way that donations and barter for strategic materials under Title III of P.L. 480 were included. The quantity that would have been purchased at market price by the recipients in the absence of these programs would also have been a component of demand.

The part of this category of exports that was a component of export demand at 1959 prices lay between the view that these four categories were entirely surplus disposal programs and the view that they were used entirely to meet nonagricultural objectives. A procedure to rigorously specify the breakdown was not readily available. As an approximation, the value of the export to the recipient country, divided by the 1959 United States domestic price, yielded an estimate of the quantity that was a component of export demand. The value of the export to the recipient country was assumed to be 25 percent of the domestic market value, the mean value of estimates made in prior studies (73, 74, 75).

The estimated values of United States agricultural exports as a component of market-clearing demand in 1959 are presented in the right-hand side of Table 19. Their total was $3,102,176,000.

Total demand for farm production in 1959

Total demand for farm production in 1959, at 1959 prices, was thus estimated to be $29,605,527,200. It was the sum of net domestic utilization of $26,503,351,200 and export demand of $3,102,176,000.

Farm production in 1959

Various measures of "farm production" and "farm output" were generated for calendar year 1959 to meet the criteria of various uses (7, 56, 71, 76, 77). Elsewhere in the present study, "farm production" was measured as the value of crop production plus the value added by livestock production. Farm production calculated in this manner had been measured by the United States Department of Agriculture in 1947-49 prices (76). Their estimate is reported in Table 20.

Table 20. United States farm production in 1959 measured in 1947-49 prices[a]

Item	Value
Total crop production	$23,130,000,000
Pasture production	2,028,000,000
Product added by livestock	9,984,000,000
Total production	$35,142,000,000

[a]Source: (76).

The aggregate yield per acre index for 28 major crops indicated that per acre yields in 1959 were about 2 percent below the mean yields for the seven year period in which 1959 was the median year (39). Crop production was adjusted upward to account for this, to approximate "normal" yields. Total adjusted value of production was $35,604,600,000 using 1947-49 prices. Total adjusted farm production stated in 1959 farm prices was $31,531,433,760.

Farm production and demand in 1959

Total demand for United States farm production at 1959 prices had been estimated in a preceding section to be $29,605,527,200, which was less than the total production of $31,531,433,760. Total demand was 93.9 percent of total production, using these values. Stated differently, excess farm production was 6.1 percent in 1959 at observed market prices.

Comparability with Census of Agriculture data

The above estimate that demand for farm production equaled 93.9 percent of total farm production in 1959 was based on United States Department of Agriculture data. Production data for agricultural subregions, for 1959, used elsewhere in the present study were based mainly on Census of Agriculture data. It was necessary to establish the comparability of United States Department of Agriculture and Census of Agriculture farm production data before accepting the estimated excess supply percentage for application to Census subregion data. In general, both sources were measuring the aggregated value of farm production for the entire farm industry. There were some differences in sources of data, timing of enumeration, and prices used.

The major difference appeared to be in the handling of inter-farm sales of feed and livestock. The cost of feed and livestock purchased by farmers was subtracted from sales and inventory increases in the calculations of farm production based on Census of Agriculture data. While this would be an appropriate procedure in determining production for a single farm, it tended to underestimate production in the aggregate. The cost to the farmer buying feed or livestock would exceed the receipts to the farmers selling because of transportation, handling, and other costs. When all farms were aggregated, farm production would be underestimated because receipts to farmers for interfarm sales would be less than the expenditures made by the farm buyers for the same goods.

The United States Department of Agriculture used procedures in estimating farm production that more properly accounted for interfarm transfers of feed and livestock. This accounted for the major differences in values reported by the two series.

Farm production was calculated from Census data for 1939, 1944, 1949, 1954, and 1959. The values were restated at 1959 farm prices and converted into a production index with 1949 production set equal to 100. These index values were considered the dependent variable and regressed with United States Department of Agriculture production index values. The r value for this regression was .9707 and t value was 6.9967, both significant at the 1 percent level.

The values used are presented in Table 21.

Table 21. Comparability of farm production data based on Census of Agriculture and USDA data

Year	Farm Production Index based on Census of Agriculture[a] 1949 = 100	Production Index USDA[b] 1947-49 = 100
1939	79.7	80
1944	95.4	97
1949	100.0	101
1954	112.4	108
1959	138.2	120

[a]Source: (57, 60).

[b]Source: (7, p. 460).

The above was considered to have established the comparability between the two series of farm production data. It was accepted that 93.9 percent of total farm production was demanded at 1959 prices, whether farm production was calculated from Census of Agriculture or United States Department of Agriculture data.

Subregions' shares of total demand in 1959

Total farm production in the United States was estimated to be \$23,316,678,130 when calculated from Census of Agriculture data. Of this, 93.9 percent was demanded at 1959 prices, or \$21,894,360,764. It was necessary to allocate this market-clearing quantity among the subregions so that adjustments between observed production and quantity demanded could be made at the subregion level.

To give recognition to changes in each subregion's share of total farm production, a regression was made of the subregion's percent of total United States farm production on time. The percentages of total United States production were calculated for each subregion using Census of Agriculture data for 1939, 1944, 1949, 1954, and 1959. The regression was evaluated for 1959 and 1980, giving an estimate of the percent of total United States market-clearing farm production that would be the subregion's share in each of those years.

The total market-clearing quantity of demand for United States farm production, estimated for 1959 in the preceding section, was allocated among the subregions in this manner.

The procedure is illustrated in Table 22, using Iowa Subregion 3 data.

Table 22. Procedure for allocating total demand for farm products to subregions in 1959

Item	Value
Total demand for United States farm production in 1959	$21,894,360,764
Farm production in Iowa Subregion 3 as a share of total United States farm production, evaluated for 1959	.010552
Iowa Subregion 3 share of total demand, 1959	$ 231,029,295

<u>Domestic demand in 1980</u>

The value of farm production demanded domestically in 1980 was estimated at the 1959 price level. The estimated value of the quantity demanded domestically in 1959 was multiplied by two demand shifters accounting for increases in total population and in per capita disposable income during the 1959 to 1980 period.

The U.S. Census Bureau projected the population of the United States to be 259,584,000 by 1980 using their Series II assumptions of fertility level continued at the 1955-57 rate (77). This would be a 46.44 percent increase over the 1959 population of 177,261,000 (78). The value of the population demand shifter would be 1.4644 based on these estimates.

The U.S. Department of Agriculture projected the value of the per capita disposable income demand shifter to be 1.02 for the 1959-1980 period (76). This value was based on a projected increase of 55 percent in real income per person by 1980.

Domestic demand for farm production in 1980 was calculated as follows using the 1959 domestic demand and the two demand shifters:

$$(\$19,599,831,752)(1.4644)(1.02) = \$29,276,033,487$$

<u>Export demand in 1980</u>

The United States Department of Agriculture projected that with an expanded Food for Peace Program exports of farm products in 1980 would be 30 to 35 percent above the 1960 level (76). The lower of these two percentages was used in the present study to estimate the 1980 export demand. If a 30 percent increase in exports was experienced from 1959 to 1980, the effective export demand would total $4,032,828,800 at the 1959 price level.

Total demand in 1980

Total projected demand for United States farm production in 1980 was calculated as the sum of the projected 1980 domestic demand of $29,276,033,487 plus projected 1980 export demand of $4,032,828,800. In 1959 prices the total projected 1980 demand was $33,308,862,287.

The above estimated demand was allocated among subregions based on their evaluated shares of total demand in 1980. The procedure used in the allocation of total demand in 1959 was followed.

Projected Land Supply and Factor Prices in 1980

It was assumed that the nonfarm demand for land in 1980 would be price inelastic at the price levels at which land would be sold for farming purposes. That is, the nonfarm demand for land would be filled first and the remainder would be available for farming use.

The supply of land to the farming industry was thus fixed, as was the case in the 1959 analysis. In the 1980 model as in the 1959 model, the supplies of capital and labor were considered to be perfectly elastic to the farm industry at their nonfarm opportunity cost rates.

Supply of farm land in 1980

Research procedures for the projection of the supply of farm land in Iowa in 1980 were developed by the author (79). The illustrations and empirical results reported for Iowa data in the following sections were also his responsibility.

The methodology was modified to fit the needs and characteristics of other states by the person in each state that was responsible to the North Central regional project for this part of the study. Empirical results for states other than Iowa were also their responsibility. The methodology and the empirical results for states other than Iowa reported in the following sections were developed by these other persons working on the project.

Supply of farm land in 1980

It was necessary to estimate the quantity of farm land that would be available for agricultural uses in 1980 in order to estimate resource and production characteristics of the farming industry. The basic procedure was to consider the supply of land in 1959 as a base and subtract from that base the estimated amounts of farm land to be converted permanently to nonagricultural uses during the 1959 to 1980 period. The residual was considered to be the supply of farm land available for farm use in 1980.

Supply of farm land in 1959 The total supply of farm land in 1959 was reported in the Census of Agriculture by commercial and non-commercial farms (23). The quantities of farm land permanently converted to non-agricultural uses during the 1959 to 1980 period were projected by types of use and by Census subregions.

Urban expansion Organizations responsible for city planning in larger urban places were surveyed concerning their projected requirements for additional farm land by 1980. The organizations included planning and zoning commissions, chambers of commerce, and city governments.

Projected land requirements for smaller urban places were determined by multiplying projected population increases by an estimated acreage requirement per person. It was estimated that .2 acre of farm land would be required for each person added to the urban population of town with less than 10,000 population in Iowa. Observed and estimated acres per person in several Iowa towns of different sizes supported use of this rate (80).

There was some variation among the states in the quantity of farm land that was estimated to be required per person added to the urban population. It was estimated in Illinois and Michigan that .25 acre would be required. In Indiana it was estimated that .16 acre would be needed, and .083 acre was estimated in Minnesota. The rest of the states used the value of .2 acre per person.

Airport facilities The Federal Aviation Agency annually prepared a National Airport Plan which included development considered necessary to provide a system of airports adequate to meet the needs of civil aviation (81). The most recent revision of the plan was based on requirements for 1963 to 1967, and estimates by the Federal Aviation Agency had not been made beyond that period. It was assumed that airport development would be carried out as indicated by the National Airport Plan, and that a linear extrapolation of the five years included in the 1963 to 1967 plan would accurately project the amount of land required for airport expansion during the 1959 to 1980 period.

<u>Highway expansion</u> A central highway authority in each state provided data concerning past acquisitions and future requirements for farm land. Land acquired for the interstate and defense system of highways was included, as well as acquisitions by counties for road improvement.

<u>Public recreation areas</u> Public recreation areas included federal reservoir projects, wetlands projects, state parks, and county recreation areas. The agencies or groups with authority provided data concerning recent expansion of facilities and projected requirements for farm land.

<u>Private recreation areas</u> The development of privately owned recreation areas was not organized, supervised, or regulated by a central planning group or common authority. Little information about its past growth was available, and projections concerning future development of privately owned recreation areas were made with difficulty in all states in the region.

County extension staffs in selected Iowa counties furnished information concerning these recreation areas in their counties. They also reported plans for future projects, including lake developments, church camps, other camps, golf courses, and vacation ranches. There was wide variation reported among Iowa counties in the private development of recreation areas. Future acquisition of farm land for this use would likely be influenced by federal reservoir and other projects, state park expansion, and county park activities. Projections of land requirements per county were based on mean recent and known future acquisitions.

In Illinois it was indicated that there would be considerable multiple use of land in private recreation areas, with little if any reduction in farm land. In another state, it was indicated that there was presently sizeable over-capacity in some types of privately owned recreation facilities even during peak usage periods.

Total nonfarm demand for land 1959-80 The preceding categories covered the major expected sources of nonfarm demand for farm land during the 1959 to 1980 period. The projections for Iowa are presented by Census subregions and types of use in Table 23.

In Kansas the total land in agricultural use had been declining in eastern areas, increasing in western areas, and increasing for the state as a whole in every recent Census period. For this reason, subregion estimates of total farm land converted to nonagricultural uses during the 1959 to 1980 period were projected using a different procedure. The percentage change in agricultural land was regressed with total land area to provide an aggregated projection of farm land converted to nonfarm uses. This procedure gave estimated totals by subregions but did not provide a breakdown by types of uses.

Demand for land by non-commercial farms The resource and production characteristics of non-commercial farms had differed historically

Table 23. Estimated acres of farm land converted to nonfarm uses during 1959 to 1980 in Iowa

	Southern Iowa	Central Iowa	Northeast Iowa	Southeast Iowa	Western Iowa	State total
Urban expansion	1,550	55,620	6,290	44,840	14,390	122,690
Airport facilities	4,400	3,000	2,200	4,000	4,000	17,600
Highway use	16,860	23,570	17,410	28,860	23,460	110,160
Federal reservoir projects	70,000	48,000	None	2,000	None	120,000
State recreation areas	860	450	1,310	30	1,180	3,830
County Conservation Board recreation areas	8,650	9,100	7,280	10,470	9,560	45,060
Private recreation areas	5,700	6,000	4,800	6,900	6,300	29,700
Total farm land converted to nonfarm use	108,020	145,740	39,290	97,100	58,890	449,040

from commercial farms. Procedures for projecting their 1980 characteristics were also different. For this reason, the demand for land by non-commercial farms was projected separately from the commercial farms.

The three kinds of non-commercial farms were described earlier in the present chapter. It was assumed that the number of part-time farms in Iowa was directly related to the urban employment opportunities available. Thus, the increase in part-time farming opportunities during the 1959 to 1980 period, and the land required by part-time farmers, were a direct function of urban expansion. The rationale for this assumption was that the farm operators could not work off the farm 100 or more days if the jobs were not available, and the increases in number of non-farm employment opportunities were closely related to increases in the population of urban places.

In Michigan off-farm employment opportunities were related to the location of industries around the state rather than to urban expansion, _per se_. Other Michigan studies were used as the basis for estimating a 20 percent increase in part-time farming during the 1959 to 1980 period in the state.

There had been a decline in both part-time and small farms in Illinois prior to the present study. No change in numbers of part-time farms during the 1959 to 1980 period, with the possibility of a decline taking place, was indicated for Illinois.

It was also indicated that a decline in part-time farming might take place in southern Indiana.

It was estimated that no change would occur in the acres held in semi-retired farms in Iowa during the 1960 to 1980 period. Data indicated that the percentage of farm operators age 65 and over had been relatively stable from 1940 to 1959, making up about 11 percent of the total farm operators in Iowa (23, 82). Assuming that this percentage remained at 11 percent during the 1960 to 1980 period and that the relative size of the holdings of farm operators age 65 and over held constant its relationship to the holdings of the remainder of the farm operators, no change would occur in the holdings of semi-retired farmers.

It was assumed that the holdings of abnormal farms in Iowa would not change significantly during the 1960 to 1980 period.

An upward trend in numbers of semi-retired farmers had been observed in Kansas. The numbers of farmers aged 45-54 years in 1959 supported projected increased numbers of semi-retired farmers for 1980.

The projected supply of farm land for commercial farms in 1980 is presented by states in Table 24. It was assumed that the demands for land for urban expansion, airport facilities, and the other kinds of uses summarized in Table 23 would be filled from land that was in commercial farms in 1959 in the proportion that land in commercial farms was to total land in farms. This implied that there was no selectivity for either category of farm land for the above uses.

The increased holdings of part-time, semi-retired, and abnormal farms, however, all required land which had been in commercial farms in 1959.

Projected factor prices in 1980

The quantities of factors demanded and their combinations on well-

Table 24. Land in commercial farms 1959 and projected supply 1980, by state

State	Land in commercial farms 1959 (acres)	Land in commercial farms 1980 (acres)	Percent decrease in supply 1959-1980
Ohio	14,914,392	13,776,992	7.6
Indiana	16,261,780	15,145,285	6.9
Illinois	28,625,797	27,849,555	2.8
Michigan	11,385,170	10,198,823	10.5
Wisconsin	19,079,877	17,882,385	6.3
Minnesota	28,318,827	27,561,964	2.7
Iowa	32,894,114	32,369,242	1.6
Missouri	27,399,281	26,511,405	3.3
North Dakota	40,312,669	39,855,123	1.1
South Dakota	43,256,083	42,331,420	2.1
Nebraska	46,978,575	46,586,830	.8
Kansas	48,092,200	47,151,854	2.0
Kentucky	9,832,769	9,130,901	7.2
Total for North Central Region	367,351,534	356,351,779	3.0

organized farms depends on their productivity and their prices. Factor prices had changed relatively and absolutely in the past and could reasonably be expected to change in the future. For this reason it was necessary to project factors prices for 1980.

Factor prices as the opportunity cost rates for labor, capital, and land in 1980 were developed by Craft (12) from projections and information compiled by Denison in his study of sources of economic growth for the United States (83).

The average rates of increase in earnings of labor, capital, and land were projected for the 1959 to 1980 period. These rates of increase in earnings were considered to be reasonable approximations of the increase in factor opportunity cost rates during the same period.

The earning rates for labor, capital, and land in 1980 were determined by dividing the projected share of gross national product allocated to each factor, by the projected index of input of that factor. This established earnings per unit of factor input for 1980. Compared to the same relationship in 1959, the average rate of increase in earnings per unit of labor, capital, and land input was calculated.

The projected increases in factor opportunity cost rates during the 1959 to 1980 period were 41 percent for labor, 13.5 percent for capital, and 28.5 percent for land. The opportunity cost rates for these factors that were used in the 1959 analyses were increased by the above percentages for the projected rates in the 1980 model. The opportunity cost rates for capital and land in 1959 and the projections for 1980 are presented in Table 25.

Table 25. Opportunity cost rates for capital and land in 1959 and projected for 1980, by states

State	Capital		Land	
	1959	1980	1959	1980
Ohio	.0630	.0715	.0542	.0696
Indiana	.0641	.0728	.0525	.0675
Illinois	.0622	.0706	.0507	.0651
Michigan	.0664	.0754	.0534	.0686
Wisconsin	.0634	.0720	.0499	.0641
Minnesota	.0665	.0755	.0504	.0648
Iowa	.0636	.0722	.0486	.0625
Missouri	.0660	.0749	.0537	.0690
North Dakota	.0657	.0746	.0503	.0646
South Dakota	.0673	.0764	.0494	.0635
Nebraska	.0593	.0679	.0494	.0635
Kansas	.0621	.0705	.0519	.0667
Kentucky	.0600	.0681	.0551	.0681

Projected Farm Resource Combinations in 1980

The combinations of resources employed in farming had changed during the years prior to the present study and were expected to continue to change in the future. Changes in relative prices of factors and the differential effects of technological advances on factor productivity provided stimuli for these changes (84). It was necessary to project the changes in resource combination in order to identify the resource characteristics of the farming industry in 1980.

The procedure for projecting the resource combination was divided into four steps. They were as follows:

a. Project the physical quantities of three classes of labor, three classes of capital, and capital consumption to 1980 based on time series trends.

b. Aggregate the projected physical quantities into labor, capital, and capital consumption and multiply by the appropriate 1980 prices.

c. Sum the total factor inputs from the preceding step and calculate the percentage that each class was of the total.

d. Reallocate the total labor, capital, and capital consumption contained in the optimal 1959 farm into the three components based on the percentages just calculated.

These four steps resulted in farm structures containing the same total capital, labor, and capital consumption inputs as the 1959 optimal farm but in the projected 1980 proportions. Additionally, these farms contained the same quantity of land input as the optimal 1959 farms.

This organization served as a starting point for the required extensification or intensification for projecting the minimum cost and market-clearing organization in 1980.

The rationale for these procedures hinged on two key assumptions:

a. The price and technological changes that prompted the shifts in resource mix during the base period would continue to prompt similar shifts in the resource mix to 1980.

b. The resource shifts in the base period were measured using data from average farms, but were assumed to be reasonable predictors of future changes on well-organized farms as well.

In making the projections for 1980, a base period of years was needed. It seemed reasonable that the base period selected should be the best representation possible of what was likely to occur from 1959 to 1980.

The period 1949 through 1963 was generally used. It began long enough after the termination of the Second World War for most of that influence to have been felt. A shorter time period was used in estimating machinery inventories because the accumulated demand for machinery from the war period appeared to carry over until 1951 or 1952.

Projection of physical quantities of inputs   Projections of physical quantities of inputs were made for three classes of labor, three classes of capital, and for capital consumption for 1980 based on time series data. Projections were made by states.

Hired labor   Hours of hired labor input were projected to 1980 from the 1949 through 1963 base period. The state totals for cash wages, perquisites, and employers' share of social security taxes (56) were converted into constant dollars (7) and divided by the composite hourly wage (85, p. 9) to generate an estimate of hours of hired labor in the base period. A downward trend was observed, and the projections for 1980 were made using a constant percentage decline. Although the data also fit a linear arithmetic function satisfactorily, a linear function would have implied the eventual elimination of hired labor as an input over time.

Family labor The total number of operators plus other family workers also displayed a downward trend in the 1949 through 1963 base period (85). Projections to 1980 were also made using a constant percentage decline.

The projected number of total operators plus other family workers in 1980 was multiplied by the months of labor per operator plus other family workers in 1959 to estimate total months of operator plus other family labor in 1980. This total was allocated between operators and other family workers in the same proportions that they were of the total in 1959. The months of labor per operator and other family workers in 1959, and the proportions of total months furnished by operator labor and by non-operator family labor in 1959 were developed from 1959 Census of Agriculture data (23).

Projections by Denison (83, p. 37) indicated that the work year in nonfarm industries would be about 10.3 months by 1980, and this figure was used as the minimum labor input per well organized farm in 1980. It was assumed that the proportion of operator labor to other family labor remained constant from 1959 to 1980. Since non-operator family labor was furnished by the operator's wife and children, to assume a change in the proportion would imply changes in family structure or changes in the willingness or need for the family to provide labor. There was no apparent basis for the latter changes.

Livestock and crop inventories Livestock and crop inventories were estimated by states for the base period 1949 through 1963. The sum of the January 1 values of cattle, hogs, sheep and chickens on farms in each year of the base period were considered to make up total livestock inventories on farms (86). Crop inventories for corn, wheat, soybeans, oats, and barley were assembled in quantity terms for January 1 of each year (87, 88) and valued in terms of January 15 prices (24). January 1 inventories of hay were estimated to be 68.1 percent of the production of the preceding year, the mean percentage that January 1 United States hay stocks were of the preceding year's production, during the 1955-60 period (7).

January 1 values of livestock and crops were summed for each year, converted to constant dollars, and a linear time series regression fitted. The regression was evaluated for 1980, yielding the projected livestock and crop inventories.

Machinery inventory Inventory value of farm machinery by states was estimated from unpublished data from the Farm Income Estimates Section of the USDA (56). The general procedure that had been used was to allocate the value of new machinery manufactured among the states each year, and calculate machinery life, annual depreciation, and remaining value by states each year. This series had been developed over a long period of time. January 1 remaining values of machinery by states were converted to constant dollars and regressed against time. The regression was evaluated for 1980 giving the projected machinery inventory.

The base period years of 1952 through 1962 were used in making the machinery inventory projections. A backlog of unfilled demand for farm machinery was filled in the years following the Second World War. Examination of the data indicated that the major effects of this abnormal demand were probably spent by 1952. Data for 1952 through 1963 seemed to provide the most reliable basis for the 1980 projections.

Stock of operating capital The stock of capital required to furnish a flow of funds for operating expense was estimated to be one-half of the total production expenses for the year. The rationale for using one-half was that productive enterprises also provide a flow of receipts to replenish the stock of capital. In many enterprises the lag between the occurrence of the productive expense and the receipt is about six months, or one-half year.

Items included in production expenses were expenditures for fertilizer, lime, repairs, fuel and pesticides, electricity and telephone, veterinarian services, medicines, taxes, and seeds (56). Livestock and feed purchased were excluded since they were implicitly counted as capital in the livestock and crop inventories.

Estimates were made for each year in the 1949 through 1963 base period, converted to constant dollars, and regressed against time in a linear regression. The evaluation of the regression for 1980 served as the projected value for 1980.

Capital consumption The term capital consumption has been used in the present study to represent the sum of production expenses and depreciation. In addition to production expenses which were estimated in projecting the stock of operating capital in the preceding section, it was necessary to project depreciation (56). Production expense and depreciation were summed, converted to constant dollars, and regressed against time in a linear regression. The years 1949 through 1963 were used for the base period. The 1980 projected values were determined by evaluating the regression for that year.

Aggregation of inputs The projection to 1980 of physical quantities of several kinds of nonland farm inputs by states was described in the preceding sections. At this stage, the inputs were physical units priced at 1959 prices. An immediate objective was to sum the three kinds of labor inputs into one labor input, the three kinds of capital inventory items into one capital input, and to aggregate these two broader categories with capital consumption. A set of factor prices was needed to make the aggregation.

Also, it was necessary to determine the percentage that each broad category was of the total to project the farm resource mix in 1980. However, since relative prices of the inputs varied over time, the percentages would vary with whatever set of input prices were used. The observed proportion of nonland inputs in 1959 for Ohio with comparisons among five possible price weighting systems for the 1980 projections are presented in Table 26 as an example of the alternatives available.

Table 26. Proportions of nonland inputs in Ohio in 1959 and comparisons with five price weighting systems for 1980 projections

Item	1959 observed proportions	1980 Projected proportions				
		1949 prices	1963 prices	Geometric mean of 1949 and 1963 prices	1959 prices	1980 prices
Value of labor input	.414	.207	.265	.235	.249	.282
Opportunity cost of capital	.098	.099	.093	.096	.094	.090
Production expense plus depreciation	.488	.694	.642	.669	.657	.628
Total	1.000	1.000	1.000	1.000	1.000	1.000

It seemed most appropriate to use the projected 1980 input prices since later stages of the analysis would be in terms of that year.

Individual inputs as percentages of total inputs The projected physical quantities of nonland inputs in 1980 were multiplied times their respective 1980 projected prices, and summed. This aggregated total was used as the denominator in calculating the percentage that each major category of nonland input was of total inputs. The three major categories were value of labor, the opportunity cost of capital, and capital consumption, i.e. production expense plus depreciation.

A comparison between the nonland factor mix on the optimally organized farms in 1959 and 1980 is presented by states in Table 27. For the North Central Region as a whole, the labor input was projected to decline from about 40 percent of the mix in 1959 to less than 30 percent in 1980. Opportunity cost of capital maintained about a constant share during the period, while capital consumption increased from about 50 percent in 1959 to 60 percent in 1980.

Recombination of inputs on well organized farms in 1980 As a first approximation for 1980, the resource and product characteristics of the optimally organized farms in the 1959 minimum cost and market-clearing reorganization were used. The total value of labor, opportunity cost of capital, and capital consumption per farm were held constant, but they were recombined in the proportions that were projected in the preceding section.

The recombined values for nonland inputs were combined with the same quantity of land associated with the optimally organized farms in

Table 27. Individual factor inputs as percentages of total nonland inputs on optimal farms in 1959 and 1980, by states, in constant prices

State	Optimal farm--1959			Optimal farm--1980		
	Value of labor input	Opportunity cost of capital	Capital consumption	Value of labor input	Opportunity cost of capital	Capital consumption
Ohio	.414	.098	.488	.282	.090	.628
Indiana	.379	.109	.512	.230	.097	.673
Illinois	.365	.098	.537	.249	.905	.656
Michigan	.459	.098	.443	.274	.087	.640
Wisconsin	.424	.105	.471	.334	.115	.551
Minnesota	.413	.109	.478	.289	.106	.604
Iowa	.394	.116	.490	.286	.102	.613
Missouri	.379	.090	.531	.320	.109	.571
North Dakota	.394	.105	.501	.236	.151	.613
South Dakota	.377	.127	.496	.241	.165	.594
Nebraska	.363	.115	.522	.250	.114	.635
Kansas	.366	.099	.535	.209	.099	.692
Kentucky	.475	.106	.419	.354	.095	.551
Mean	.400	.106	.494	.273	.110	.617

1959. This gave the resource characteristics of minimum cost organization farms in 1980, but without consideration of industry effects. Changes in resource productivity from 1959 to 1980 and extensification or intensification to determine the market-clearing situation are discussed in the following section.

Projected Market-Clearing Organization in 1980

Resource productivity in 1980

Procedures for projecting farm resource combinations in 1980 were discussed in the preceding sections. The resource characteristics were first projected for farms in 1930 and were used as starting points in determining the minimum cost and market-clearing organizations.

In general, the total value of the bundle of labor, capital, capital consumption, and land per optimally organized farm in 1959 were projected intact to the 1980 farms in value terms. However, the proportions of the first three were shifted with relatively more capital consumption and less labor per farm in 1980 than in 1959, as indicated in Table 27.

The next step was to project the quantity of production that would be generated per farm in 1980 by the new combination of resources. The technique used was to multiply the quantity of production that the resources generated per farm in 1959 by an appropriate coefficient that represented increased productivity of resources expected during the 1959 to 1980 period.

Rate of factor productivity increase 1959-1980 Productivity measures the volume of output per unit of input. The historic trends in the index of agricultural productivity in the United States were used as guides in projecting the increase in productivity from 1959 to 1980. While there are fundamental questions concerning how, if at all, factor productivity changes over time, the key consideration in the present study was that measured productivity had changed. It was used as a basis for projections (89).

The index of agricultural productivity had been calculated as the ratio of the index of total farm output to the index of total farm inputs. The exclusion of inputs of public investment in education, research, and health probably resulted in an upward bias in the index to the extent that the public inputs may have risen faster than measured inputs (90, p. 48).

Additionally, the index was sensitive to the effects of weather on crop production, since crop production was a major component of total output. Thus, the measurement of the role of productivity increase over time was sensitive to the period of years selected for the base.

The productivity of United States agriculture displayed only a slight upward trend from 1910 until the 1930's, but since that period a sharp upward trend has been the rule. If the trend was measured for the period of 1937 through 1958 it would have excluded major effects of unusually bad or good weather on crop production and on the index of productivity, but would not have included any productivity increases of the most recent six years. The 1.3 percent compounded rate of increase for that period could probably be considered the absolute minimum rate of increase for the base period.

If the trend line had been measured for the most recent 30 year period for which data were available, 1933 through 1963, the productivity increase would have been 1.75 percent compounded annually. This trend line would be steeper than the preceding because of including the relatively low productivity drouth years near the beginning of the period and relatively favorable weather years near the end, and because the productivity increases of the last six years were also included. The 1.75 percent rate of increase could be considered to be within the range of probable productivity increase in the base period.

The trend line was also measured for the years beginning after the adjustment period following the Second World War. For the 13 years from 1950 through 1963 the productivity increase was 2 percent per year compounded annually. This time period measured the productivity for the most recent period of years but also contained years when weather was unusually favorable for crop production. The 2 percent rate of increase could be considered to be about the maximum rate of productivity increase.

It appeared that the rate of productivity increase could have ranged from 1.3 percent to 2 percent compounded annually. Implicit in the above measurements was the assumption of linearity of the trend line, which was supported by examination of the data.

The rate of productivity increase discussed in the preceding was based on data from all farms in the United States. In the present study, the projected role of productivity increase on optimally organized farms from 1959 to 1980 was required. Craft (12) estimated the inputs and outputs of the top one-third farms in the southern Iowa farm business association from the years 1948-50 to 1958-60. He indicated that the productivity of inputs on these farms increased at an annual rate of about 2.5 percent, compared to about 2 percent for the industry.

Considering the range in productivity increases estimated for the base period, the apparent linearity of the trend line since 1930, and the productivity increase of well-organized farms in southern Iowa, it was decided to project the resource and production characteristics of the farm industry for 1980 for four rates of growth. The rates were 1.5 percent, 1.75 percent, 2.0 percent, and 2.25 percent compounded annually. The evidence seemed to indicate that a fairly high probability could be attached to the true value in the base period being between 1.75 and 2.0 percent compounded annually.

The estimating procedure

The analytical procedures followed in the 1980 analysis paralleled those used in the minimum cost and the market-clearing reorganizations for 1959. The resource structures of the optimally organized 1959 farms were projected intact to 1980 conditions as a first approximation of minimum cost farm organization in 1980. The nonland inputs per farm were reproportioned according to projected trends but their total value was held constant and combined with the same value of land as in the optimal 1959 situation. However, because of the assumed increased factor productivity during the 1959-1980 period, the per farm level of output would have been larger than in 1959.

The number of farms per subregion had declined during the 1959-1980 period because of the projected decline in the supply of land available for commercial farms. The subregion shares of total demand for farm production in 1980 were projected in a preceding section, using 1959 prices. The price elasticity of demand for farm production had also been projected for 1980 and projections of relevant factor prices had been made (54).

The equations used for the 1980 projections were similar to those used for the 1959 estimates. Modifications in the equations were introduced to account for the projected changes in resource combinations, resource productivity, commercial farm land base, and product demand between 1959 and 1980. A series of 22 equations were developed to systematically compute values for the unknown variables in the 1980 minimum cost and market-clearing situation.

Exogenous variables The preceding sections of this chapter discussed how values for certain exogenous variables were empirically projected for use in the 1980 model. Additional information from the observed and optimal 1959 situations were used. The 15 known variables were as follows:

X_1 = price of land per acre in 1959.

X_2 = gross production per acre on non-commercial farms in 1959

X_3 = projected acres in non-commercial farms in 1980

X_4 = subregion share of total 1980 demand for farm production

X_5 = supply of land available for commercial farms in 1980

X_6 = percentage of aggregated nonland inputs that was opportunity cost of capital in 1980, per farm

X_7 = percentage of aggregated nonland inputs that was value of labor input in 1980, per farm

X_8 = percentage of aggregated nonland inputs that was capital consumption in 1980, per farm

X_9 = aggregated nonland inputs per optimally organized farm in 1959

X_{10}= opportunity cost rate for capital in 1980

X_{11}= opportunity cost rate for land in 1980

X_{12}= man-months of labor per optimally organized farm in 1959

X_{13}= value of labor input per optimally organized farm in 1959

X_{14}= value of land per optimally organized farm in 1959

X_{15}= gross production per unit of land on optimally organized farms in 1959

It was indicated in a preceding section that four separate projections of the characteristics of the farm industry in 1980 were made, for each of the four projected rates of increase in resource productivity. The rates of increase in resource productivity were indicated by G_j, where $j = 1, 2, \ldots, 4$ rates of increase.

The values of eight additional variables were determined independently of the increase in factor productivity and the product price level. That is, their values remained constant for all levels of G_j. They were designated as Y variables, and the equations used to compute their values are described in the following paragraphs.

It was assumed that non-commercial farms operated outside the realm of economic efficiency and income maximization, and that their level of output would be independent of the product price in 1980. Additionally, their rate of resource productivity increase was assumed to be lower than for commercial farms. In support of these assumptions was the large differential in gross production per acre between commercial and non-commercial farms in 1959. In the 71 subregions of the North Central Region, the former averaged \$74 per acre while non-commercial farms generated about one-fifth as much, \$16 per acre.

Total gross production by non-commercial farms in 1980 was projected by multiplying the product of gross production per acre in 1959 and projected acres in non-commercial farms in 1980 times a coefficient representing an increase in resource productivity of 1.5 percent compounded annually. This variable was Y_1:

$$Y_1 = (X_2)(X_3)(1.367058)$$

The subregion share of total 1980 demand for farm products minus the production generated by the non-commercial farms yielded the subregion share of 1980 demand that had to be met by commercial farms. This variable was designated as Y_2:

$$Y_2 = (X_4) - (Y_1)$$

The projected acres of farm land that were expected to be available for commercial farms in 1980 were multiplied times the observed land price per acre in 1959 to provide a measure of the total land input that was consistent with land input in the 1959 analyses:

$$Y_3 = (X_1)(X_5)$$

The opportunity cost of capital per farm, Y_4, was estimated as the product of aggregated value of nonland inputs per optimally organized farm in 1959 multiplied by the projected proportion of the aggregated value of inputs that the opportunity cost of capital would be in 1980:

$$Y_4 = (X_9)(X_6)$$

The input of capital per farm was obtained by dividing the opportunity cost of capital per farm by the projected 1980 opportunity cost rate. This variable was Y_5:

$$Y_5 = \frac{(Y_4)}{(X_{10})}$$

Value of labor input per farm in 1980 was designated as Y_6. It was the product of aggregated nonland input per optimally organized farm in 1959 times the projected proportion of the aggregated input that value of labor input would be in 1980:

$$Y_6 = (X_9)(X_7)$$

The capital consumption per farm in 1980 was projected in a similar manner, using the projected proportion of the aggregated input that capital consumption per farm would be in 1980:

$$Y_7 = (X_9)(X_8)$$

Man-months of labor per farm in 1980 was projected by multiplying the ratio of the projected value of labor input per farm in 1980 to the value of labor per optimally organized farm in 1959 times the man-months of labor per optimally organized farm in 1959. This variable was identified as Y_8:

$$Y_8 = \frac{(Y_6)}{(X_{13})} \quad (X_{12})$$

The values of two additional variables were dependent upon product price level, P_i, but were independent of the rate of factor productivity increase. $P_i = 1, 2, \ldots, n$ where n is the number of different price levels used.

Endogenous variables The physical quantity of farm production demanded from a subregion at the P_i price level was a function of the quantity that would have been demanded at the 1959 product price level and the projected price elasticity of demand for farm products. Farm production was identified and calculated as follows:

$$Z_1^{\ i} = (1.23 - .23\ P_i)(Y_2)$$

The dependent variable in the extensification regression, $\hat{Y}$, was designated as $Z_2^{\ i}$. It referred to gross production per unit of land and was calculated by dividing the quantity of production demanded in 1980 by the value of the land input:

$$Z_2^{\ i} = \frac{(Z_1^{\ i})}{(Y_3)}$$

The rest of the endogenous variables were dependent on both the product price level and rate of increase in resource productivity. $Z_3^{\ ij}$ represented the X variable in the extensification regression, capital plus labor input per unit of land. It was projected as follows:

$$Z_3^{ij} = \frac{(Z_2^{i}) - (X_{11}) \dfrac{(X_9)}{(X_{14})}}{(X_{15})(G_j) - (X_{11})}$$

The number of farms in a subregion was determined by multiplying the capital plus labor input per unit of land times the quantity of land available, and then dividing that product by the capital plus labor input per optimally organized farm in 1959. The number of farms was indicated by Z_4^{ij}:

$$Z_4^{ij} = \frac{(Z_3^{ij})(Y_3)}{(X_9)}$$

Z_5^{ij} was the total capital input per subregion, the product of capital input per farm times the number of farms:

$$Z_5^{ij} = (Y_5)(Z_4^{ij})$$

The acres per farm, Z_6^{ij}, was determined by dividing the acres of land available for commercial farms by the projected number of farms:

$$Z_6^{ij} = \frac{(X_5)}{(Z_4^{ij})}$$

The value of land and buildings per farm was calculated by dividing the value of land and buildings available by the number of farms. This variable was Z_7^{ij}:

$$Z_7^{ij} = \frac{(Y_3)}{(Z_4^{ij})}$$

Total revenue to the farm industry was the product that resulted from multiplying the physical quantity produced times the price level at which that quantity would have cleared the markets. Dividing by the number of farms gave the total revenue per farm, Z_8^{ij}:

$$Z_i^{ij} = \frac{(Z_1^{i})(P_i)}{(Z_4^{ij})}$$

Factor earnings per farm, Z_9^{ij}, were determined by subtracting production expenses and depreciation from total revenue:

$$Z_9^{ij} = (Z_8^{ij}) - (Y_7)$$

Opportunity cost of land per farm was the value of land times the projected 1980 opportunity cost rate:

$$Z_{10}^{ij} = (Z_7^{ij})(X_{11})$$

Total opportunity cost per farm was the sum of the opportunity costs of land, labor, and capital per farm and was designated as Z_{11}^{ij}.

$$Z_{11}^{ij} = Z_{10}^{ij} + Y_6 + Y_4$$

Total man months of labor per subregion was calculated by multiplying the man months per farm times the number of farms:

$$Z_{12}^{ij} = (Y_8)(Z_4^{ij})$$

The residual to land when non-land opportunity costs were subtracted from factor earnings was capitalized into a value per acre by dividing by the opportunity cost rate for land. The value of land per acre thus determined was designated Z_{13}^{ij}.

$$Z_{13}^{ij} = \frac{(Z_9^{ij}) - (Z_{11}^{ij}) + (Z_{10}^{ij})}{(Z_6^{ij})(X_{11})}$$

The marginal value product of land capitalized into a value per acre was designated as Z_{14}^{ij}. It was calculated by multiplying the marginal physical product of land times the product price level, and dividing by the opportunity cost rate for land:

$$Z_{14}^{ij} = \frac{(Z_8^{1.0}) - \frac{Z_1^{.5}}{Z_4^{.5}} \div (Z_6^{1.0}) - (Z_6^{.5}) \quad P_i}{(X_{11})} ,$$

where superscripts 1.0 and .5 refer to specific values of P_i.

In the discussion of the 1959 extensification regression as an interfarm production function in a preceding chapter, it was indicated that the relevant segment of the production surface appeared to be linear. That is, among the selected group of well-organized farms, the relationship between inputs of capital plus labor per unit of land and gross production per unit of land appeared to be linear. It would be untenable to assert that this phenomenon existed over the entirety of the production surface.

This relationship was assumed to hold only within or near the range of experience of the regression. The marginal physical product of land would be constant, which simplified the determination of Z_{14}^{ij} above.

Empirical results

The resource and production characteristics of farming in the North Central Region in 1980 under minimum cost and market-clearing conditions as projected by the procedures described in the preceding sections are discussed in the following chapter.

RESULTS

The empirical projections of the characteristics of the farming industry in the North Central Region in 1980 are presented and discussed in this chapter. The projections are normative in nature, describing the minimum cost organization of farms in a farming industry whose total production cleared markets at prices that just covered factor opportunity costs. The chapter has six major parts:

a. Projections for the aggregated North Central Region for 1980, under the assumption that factor productivity increased 1.75 percent per year, are first compared with the 1959 observed situation and 1959 minimum cost and market-clearing reorganizations.

b. The projections for 1980 for the aggregated North Central Region under four rates of factor productivity increase are presented and discussed.

c. The effect on the above results when factors employed in farming were paid rates of return less than their nonfarm opportunity cost rates are indicated in the third major section.

d. The effect on the preceding projections of an alternative assumption concerning the elasticity of demand for farm products is presented in the fourth section.

e. Some relevant projected characteristics for interstate sub-regions in 1959 and 1980 are presented and compared with other studies in the fifth section.

f. The limitations of the present study are discussed in the final section.

The 1980 resource and production characteristics for the farm industry in each of the 71 intrastate Census subregions are reported in the supplementary tables (22).

Characteristics in 1959 Compared with 1980

The resource and production characteristics of the farm industry in the aggregated North Central Region are reported in Table 28. The estimates for the 1959 observed situation and the 1959 minimum cost and market-clearing reorganizations had been reported in appropriate earlier chapters. The 1980 projections are reported under the condition that factor productivity increased at the rate of 1.75 percent compounded per year.

In general, the major adjustments in the farm industry that are reported in Table 28 took place in reorganizing the 1959 farm industry into a situation in which farms were organized at the minimum cost level of production and industry output cleared markets at prices covering factor opportunity costs, under the 1959 demand, factor price, and technological conditions.

The projections for the comparable 1980 minimum cost and market-clearing situation were generally similar. However, total production was higher and product price lower in 1980, and labor input per farm was also lower.

The number of commercial farms exceeded 1.1 million in the observed 1959 situation and totaled about 331,000 in the 1980 projections. In

Table 28. Resource and production characteristics of farming in the North Central Region under the observed situation and market-clearing reorganizations in 1959 and under one minimum cost and market-clearing situations in 1980, when farm product demand has constant elasticity

	Observed 1959 situation	Minimum cost reorganization 1959	Percent change from 1959 observed situation	Market-clearing reorganization 1959	Percent change from 1959 observed situation	1980 Minimum cost and market-clearing situation with productivity increase 1.75% compounded annually	Percent change from 1959 observed situation
Subregion totals:							
Number of farms	1,171,000	714,000	- 39	306,000	- 74	330,600	- 72
Acres of land	367,350,000	357,350,000	0	367,350,000	0	356,350,000	- 3
Value land and buildings[a]	$52,720,000,000	$52,720,000,000	0	$52,720,000,000	0	$51,315,000,000	- 3
Months of labor	19,002,000	14,949,000	- 21	6,420,000	- 66	4,893,000	- 74
Value of capital	$21,599,000,000	$28,571,000,000	+ 32	$12,183,000,000	- 44	$11,970,000,000	- 45
Gross production	$10,275,000,000	$20,389,000,000	+ 98	$ 9,141,000,000	- 11	$15,290,000,000	+ 49
Product price (1959 = 1.00)	1.00	1.00		.97		.66	- 34
Per farm:							
Acres of land	314	515	+ 64	1,200	+282	1,078	+243
Value land and buildings[a]	$45,000	$74,000	+ 64	$172,000	+282	$155,000	+243
Months of labor	16.2	20.8	+ 28	20.8	+ 28	14.8	- 9
Value of capital	$18,400	$39,900	+116	$39,900	+116	$36,200	+ 96
Gross production (total revenue)	$8,800	$27,500	+213	$29,900	+240	$30,500	+248
Factor earnings	$3,000	$15,300	+409	$17,800	+492	$15,800	+425
Factor opportunity cost	$9,400	$15,300	+ 62	$17,800	+ 89	$15,800	+ 68
Observed land price 1959	$144	--	--	--	--	--	--
Residual to land capitalized into a value per acre	< 0	$135	--	$97	--	$94	--

[a]Valued at observed 1959 land price.

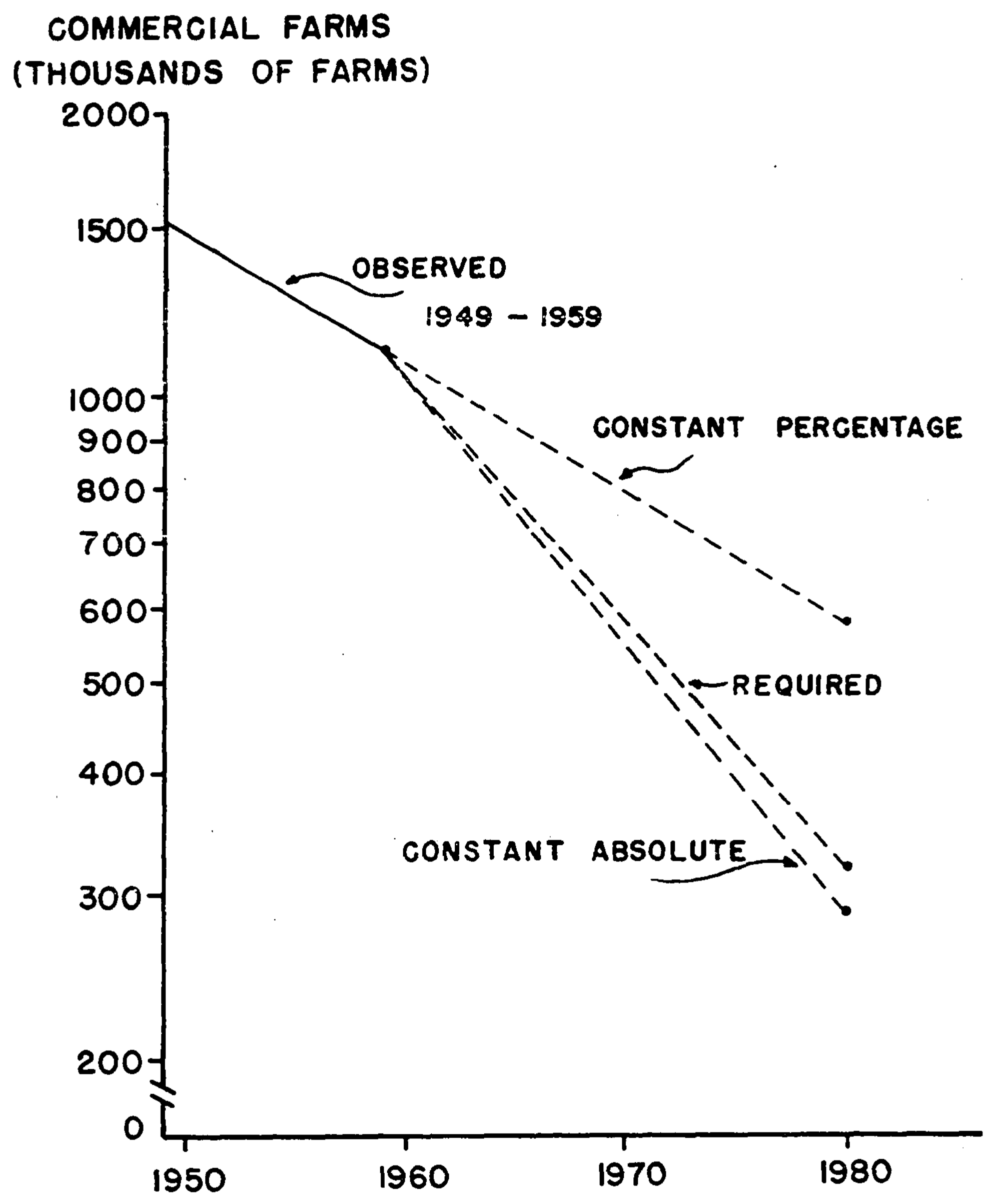

Figure 2. Projected numbers of commercial farms in the North Central Region in 1980, based on constant percentage change, required change to reach efficiency conditions, and a constant absolute change from the 1949-1959 base

Figure 2 the observed numbers of commercial farms during the period from 1949 to 1959 are indicated by the solid line, based on Census of Agriculture data. The number of commercial farms in 1980 when the 1949-59 base was projected at a constant percentages change would be greater than the number of farms projected for the 1980 minimum cost and market-clearing efficiency conditions. When the 1949-59 base was projected at a constant absolute change per year, the number of farms in 1980 would be slightly less than in the 1980 minimum cost and market-clearing situation.

Another comparison concerning the changes required in numbers of commercial farms to reach the number indicated in the 1980 minimum cost and market-clearing situation is presented in Table 29. Under the condition that productivity increased at the rate of 1.75 percent per year, there would be 330,599 commercial farms in the 1980 minimum cost and market-clearing situation. That total is broken down by states in the table.

A projection of the number of farm operators available in 1980 was also included in Table 29. This projection was made by subjecting the number of commercial farm operators reported in the 1959 Census of Agriculture to projected mortality rates appropriate for their age distribution. Additionally, it was assumed that all other operators retired at age 65 and that the number of new entrants to farming equalled the number of farmers leaving operator status for all other reasons. The number of commercial farm operators that would be available in 1980 under those restrictive conditions totaled 415,363, exceeding the projected farming opportunities by about 25 percent.

Man-months of labor on commercial farms declined from 19 million in the

Table 29. Supply of farms per state compared with number of farm operators demanding farms under specified conditions, 1980

State	Supply of farms per state in the 1980 minimum cost and market-clearing situation if factor productivity increased 1.75% per year	Farm operators available per state in 1980, assuming normal mortality, retirement at age 65, and number of entrants equalling number of quits
Ohio	17,200	27,741
Indiana	20,500	27,226
Illinois	34,700	43,831
Michigan	15,600	20,703
Wisconsin	35,500	38,633
Minnesota	31,300	44,743
Iowa	37,200	58,967
Missouri	31,700	30,432
North Dakota	15,000	19,727
South Dakota	16,500	19,729
Nebraska	30,900	29,962
Kansas	27,200	26,595
Kentucky	17,300	27,069
Total	330,600	415,363

1959 observed situation to less than 5 million in the 1980 minimum cost and market-clearing situations. The observed changes in man-months of labor on commercial farms in the North Central Region are represented by a solid line in Figure 3, for the period 1939-59. When that base period was projected at a constant percentage change to 1980, the value was slightly greater than the man-months of labor projected for the 1980 minimum cost and market-clearing situations. However, projecting the base at a constant absolute change would have reduced the supply of labor on farms to zero before 1980, an unrealistic supposition.

The market-clearing 1959 reorganization was accomplished by realloca-

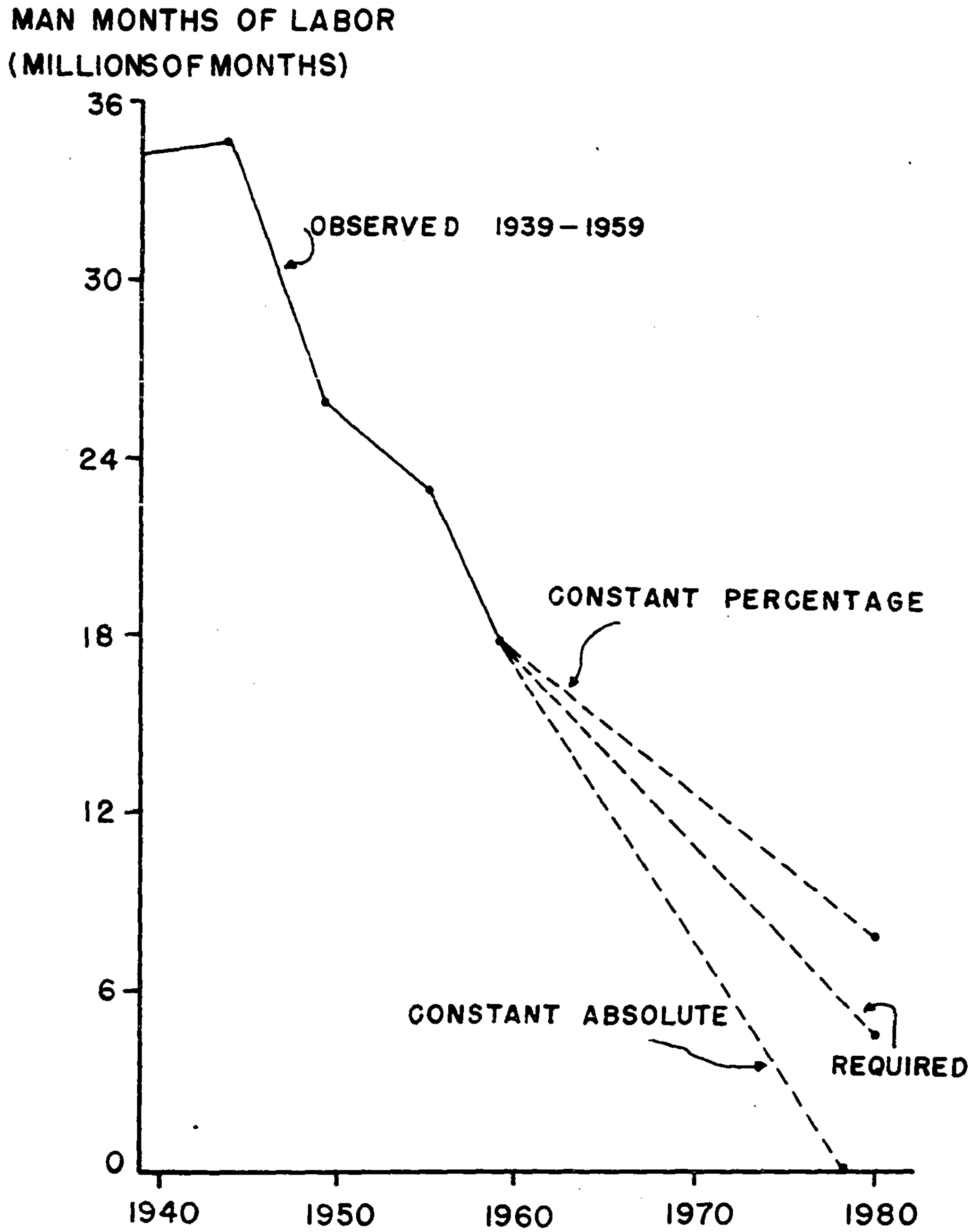

Figure 3. Projected man months of labor on commercial farms in the North Central Region in 1980, based on constant percentage change, required change to reach efficiency conditions, and constant absolute change from the 1939-59 base

ting the regional land base into farms that were extensively organized. This resulted in a sizeable decrease in labor and capital input in the region. The value of the capital input declined from about $21.6 billion in the observed 1959 situation to about $12 billion after the market-clearing reorganization in 1959 and about held that level in the 1980 market-clearing situation. These comparisons are presented graphically in Figure 4. Nonland capital was an aggregation for the states in the North Central Region of the value of machinery, feed inventories, livestock inventories, and the value of the stock of capital required to furnish a flow to pay operating expenses. The observed aggregated level trended upward during the 1949-62 period. The value of machinery input during that period was about constant, but there was a fairly substantial, continuous increase in the stock of capital required for operating expenses. Livestock and feed inventories generally trended upward during that period in an irregular pattern.

Characteristics in 1980 for Four Rates of Factor Productivity Increase

In the preceding chapter it was indicated that estimates of the rate of increase in factor productivity varied with the period of years selected as a base. A range within which the true value of measured annual factor productivity increase probably fell was estimated, and the 1980 minimum cost and market-clearing solutions for each of four points in that range were projected. The rates were 1.5 percent, 1.75 percent, 2.0 percent, and 2.25 percent compounded annually.

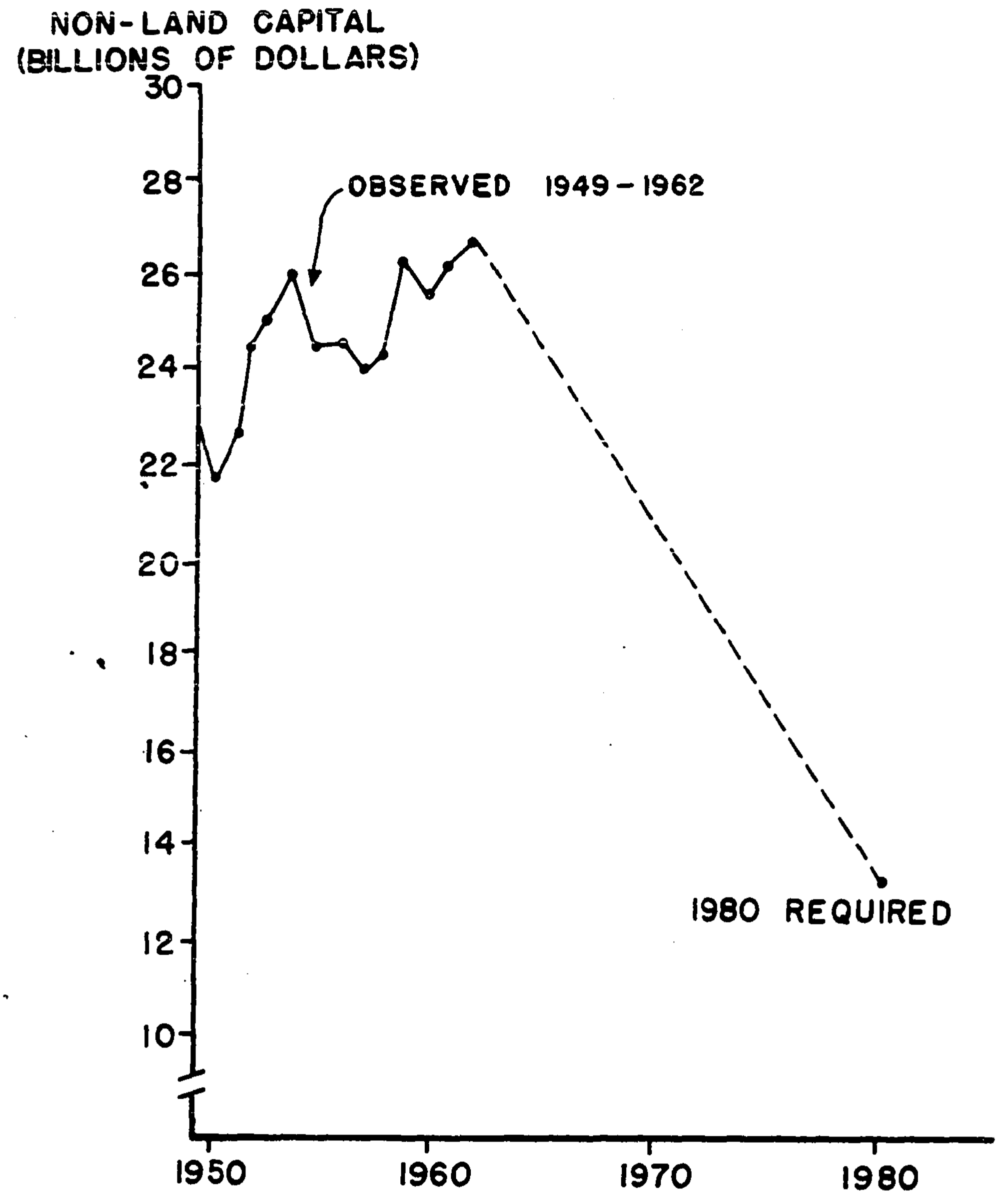

Figure 4. Observed level of non-land capital input in the North Central Region 1949-62, and projected level under 1980 efficiency conditions

The minimum cost and market-clearing characteristics of the farm industry in 1980 under those four rates are presented in Table 30. Factor productivity increase at the rate of 1.75 percent was included in Table 29, where it was compared with various 1959 situations.

In general, when resource productivity was assumed to increase at relatively high rates, less labor and capital would be required in the aggregated North Central Region. There would also be a greater volume of production generated; product prices would be lower, and total value of production would be lower.

There would be more acres per farm at the higher rates of productivity increase. The value of land declined, however.

Farm Factors Paid Less than Their Nonfarm Opportunity Costs

The analysis to this point had been carried out under the explicit assumption that farm operators were income maximizers. This was a reasonable assumption for a first approximation since farm operators must hold this objective in some degree of intensity to remain in business over time. Income maximization had the advantage of being a relatively uncomplicated objective to quantify for analysis, also.

However, farm operators hold goals other than income maximization, some of which may be in conflict. Some guidelines for the direction and magnitudes of the changes in the projections that might be expected if non-income goals were given consideration were developed. The minimum cost and market-clearing characteristics of the farm industry in 1980

Table 30. Minimum cost and market-clearing characteristics of the farm industry in the North Central Region in 1980 with four rates of resource productivity increase, when farm product demand has constant elasticity

	Factor productivity increase per year, compounded			
	1.5 percent	1.75 percent	2.0 percent	2.25 percent
North Central Region totals:				
Number of farms	346,300	330,600	314,900	300,700
Acres of land	356,350,000	356,350,000	356,350,000	356,350,000
Value of land and buildings[a]	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000
Months of labor	5,126,000	4,893,000	4,661,000	4,451,000
Value of capital	$12,540,000,000	$11,970,000,000	$11,400,000,000	$10,890,000,000
Gross production (volume)	$15,038,000,000	$15,293,000,000	$15,514,000,000	$15,754,000,000
Equilibrium product price (1959 = 1.00)	.71	.66	.62	.58
Per farm:				
Acres of land	1,029	1,078	1,131	1,185
Value of land and buildings[a]	$148,000	$155,000	$163,000	$171,000
Months of labor	14.8	14.8	14.8	14.8
Value of capital	$36,200	$36,200	$36,200	$36,200
Gross production (total revenue)	$30,800	$30,500	$30,500	$30,400
Factor earnings	$16,100	$15,800	$15,800	$15,700
Factor opportunity costs	$16,100	$15,800	$15,800	$15,700
Residual to land capitalized into a value per acre	$102	$94	$89	$83

[a]Valued at observed 1959 land price.

were projected under the condition that factors employed in farming did not receive their nonfarm opportunity costs. All efficiency conditions would still be met in these projections except that the level of production was too great that product prices were not high enough to pay factors their nonfarm opportunity costs. It was assumed that farm operators had foregone having their resources earn their opportunity costs but had gained other non-income objectives which they associated with farming or rural living. The analyses was carried out only for the aggregated North Central Region.

Six rates of return to farm factors were compared, representing various degrees of substitution of income for non-income goals. They are presented in Table 31. The highest rate, 100 percent of nonfarm opportunity cost rates, was the same 1980 projection that was presented previously in the comparisons among factor productivity increases in Table 30 and in the 1959 and 1980 comparisons in Table 28. The 1.75 percent rate of increase in factor productivity was used at all levels in this analysis.

The second column in Table 31 represents the situation in which farm operators accepted 90 percent of the nonfarm opportunity cost rate for the services of their factors, and so on for other rates in the other columns. The equilibrium product price level for each level of factor return was determined by equating the capitalized residual return to land when nonland factors had been paid their reduced returns with the capitalized marginal value product of land. This procedure was the same as had been used in the 1980 model, described in the preceding chapter.

Table 31. Minimum cost and market-clearing characteristics of the farm industry in 1980 with farm factors paid less than nonfarm factors, when farm product demand has constant elasticity

	Farm factor opportunity cost rates as a percentage of nonfarm opportunity cost rates					
	100 percent	90 percent	80 percent	70 percent	60 percent	50 percent
For the North Central Region:						
Number of farms	330,600	336,700	343,400	350,600	356,500	365,100
Acres of land	356,350,000	356,350,000	356,350,000	356,350,000	356,350,000	356,350,000
Value of land and buildings[a]	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000
Months of labor	4,893,000	4,984,000	5,082,000	5,190,000	5,278,000	5,403,000
Value of capital	$11,970,000,000	$12,190,000,000	$12,430,000,000	$12,700,000,000	$12,910,000,000	$13,220,000,000
Volume of production	$15,290,000,000	$15,510,000,000	$15,750,000,000	$16,020,000,000	$16,230,000,000	$16,540,000,000
Value of production	$10,090,000,000	$9,620,000,000	$9,140,000,000	$8,650,000,000	$8,280,000,000	$7,770,000,000
Equilibrium product price (1959 = 1.00)	.66	.62	.58	.54	.51	.47
Per farm:						
Acres of land	1,078	1,058	1,038	1,016	999	976
Value of land and buildings[a]	$155,000	$152,000	$149,000	$146,000	$144,000	$141,000
Months of labor	14.8	14.8	14.8	14.8	14.8	14.8
Value of capital	$36,200	$36,200	$36,200	$36,200	$36,200	$36,200
Gross production (total revenue)	$30,500	$28,600	$26,600	$24,700	$23,200	$21,300
Factor earnings	$15,800	$13,800	$11,900	$9,900	$8,500	$6,600
Residual to land capitalized into a value per acre	$94	$89	$83	$77	$75	$65

[a]Valued at observed 1959 land price.

In the model, farm operators reacted to the lower cost and perfectly elastic supply of nonland inputs by employing more of them and by combining them with the fixed land supply in the region. This reduced the marginal physical product of nonland inputs and increased the marginal physical product of land. With the lowered product price level, this lowered the marginal value product of land relatively less than for the other factors.

The lower factor costs and increased production resulted in a lower product price level.

The projections in Table 31 incorporate a level of production imbalance into the equilibrium 1980 situation. That is, at opportunity cost rates less than 100 percent of the nonfarm rate, the level of farm production was so great that factors employed on farms organized at their minimum cost level of output did not earn as much as in their nonfarm alternatives. Some of the contribution of the farm industry to national income would be foregone, but some non-income goals would be realized by the farm sector in making this sacrifice.

A resource cost imbalance could also have been incorporated into the model to represent a situation in which factor-factor, factor-product, or product-product relationships deviated from the efficient combinations indicated by their price ratios. Some non-income goals of farm operators could be realized in this manner. This imbalance was not explored, but it would have generated more farming opportunities but with lower factor earnings than in the 1980 equilibrium situation.

A resource cost imbalance would have been generated only in a situation in which differential rates of returns to factors existed. For example, if the farm operator would accept a lower rate of return for his labor input than for his capital input relative to their opportunity costs, he would use relatively more labor to capital than if efficient factor-factor relations prevailed. If a level of factor return was received that was the same for all factors, however, then a resource cost imbalance would not result, even if all factors received less than 100 percent of their nonfarm opportunity cost rates.

The resource cost imbalance was not explored quantitatively in the present study. If empirical evidence would be developed that indicated which of the infinite number of combinations of differential rates of factor returns were acceptable to farm operators, then a meaningful analysis could be made for that situation.

Two major observations could be made from the projections reported in Table 31. The first concerns the effect of a relatively small increase in total production on factor earnings per farm. At the 100 percent rate of return to factors, volume of production for the aggregated North Central Region was $15.3 billion compared to $16.5 billion if the 50 percent rate of return was assumed. In both cases, volume of production was priced at 1959 product prices for comparison purposes. Because of the price inelastic demand for farm products, this 8 percent increase in volume of production generated a decline in farm product prices from .66 to .47, where 1959 prices equaled 1.00. Total revenue fell from $10.0 billion to $7.8 billion for the Region.

On a per farm basis, total revenue fell from about $30,500 to $21,300, but since the operating expenses per farm had not decreased, there was a disproportionate fall in factor earnings. The individual farms contained the same level of capital and labor input but about 10 percent less land at the 50 percent rate of return to factors compared to the 100 percent level. But factor earnings per farm had declined from about $15,800 to $6,600, concomitantly with the 8 percent increase in aggregate volume of production.

The second observation based on the projections in Table 31 concerns the relatively small increase in number of farming opportunities that would be generated by a sizeable lowering of the rate of return to factors accepted by farm operators. If farm operators accepted 50 percent of the nonfarm opportunity cost rate for use of their factors, there would be about a 10 percent increase in the number of farming opportunities, from about 330,600 to 365,000.

Implicit in the above comparison was the assumption that farmers accepted equally low rates of return for all factors. If they would accept a rate of return for labor lower than those included in Table 31, then the number of farming opportunities would be larger. This could take place even though the minimum rate of return on other factors was at some higher level. As indicated earlier, if empirical estimates of the differential rates of returns acceptable to farm operators would be developed, then a meaningful analysis could be made for that situation, including the projected number of farming opportunities.

Alternative Assumption Concerning Elasticity of Demand

The preceding discussion and the projections reported in Tables 28, 29, 30, and 31 were based on a demand function for farm products that was assumed to be linear in logarithms. The demand equation was expressed as:

$Q = aP^{-.23}$, or

$\log Q = \log a - .23 \log P$, where

Q = quantity of farm products demanded

P = price of farm products

a = a constant

$-.23$ = projected price elasticity of demand for farm products in 1980.

Empirical evidence which could be used to establish the price elasticity of demand for farm products at the price levels considered in the present study was not available. It could reasonably be assumed, however, that as farm product prices declined from the 1959 level, United States farm production would at some price become more competitive in world markets. Additionally, as farm product prices declined, price relationships would shift so that it would be economically feasible to use some farm products as industrial inputs in production processes not presently in widespread use. These two demand components would tend to make the assumption that the demand function was linear in logarithms appear to be reasonable (91).

However, since the projections pertain to product price levels beyond empirical experience, an alternative assumption concerning elasticity of demand for farm products was considered.

Table 32 reports the characteristics of the minimum cost and market-clearing farm industry in the North Central Region in 1980 under four rates of resource productivity increase, with an arithmetically linear demand function. Data are directly comparable to those presented in Table 30, which represent the same conditions with the exception that the demand function was linear in logarithms (had constant price elasticity) instead of being arithmetically linear. At any given product price level, the quantity of production demanded would be relatively less under the assumption of an arithmetically linear demand function. Thus, in Table 32, the level of aggregate production is less than the level presented in Table 30, for any price level. With a lower level of production, less labor and capital would be required in the aggregate, and there would be fewer, more extensively organized farms.

In Table 33, the characteristics are reported for the 1980 situation in which farms factors would be paid less than their nonfarm opportunity cost rates. The data are comparable to those presented in Table 31, the difference again being the assumptions concerning the shape of the demand schedule. As in the preceding comparison, the arithmetically linear demand function has a relatively smaller quantity of production demanded for any given price level, with the concomitant lower aggregate inputs of capital and labor and fewer, more extensive farms.

Interstate Subregion Characteristics

As indicated in the preceding chapters, empirical results for the

Table 32. Characteristics of the minimum cost and market-clearing farm industry in the North Central Region in 1980 with four rates of resource productivity increase, linear arithmetic demand function

	Factor productivity increase per year, compounded			
	1.5%	1.75%	2.00%	2.25%
North Central Region totals:				
Number of farms	340,100	322,100	304,600	288,300
Acres of land	356,350,000	356,350,000	356,350,000	356,350,000
Value of land and buildings[a]	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000
Months of labor	5,033,000	4,767,000	4,508,000	4,267,000
Value of capital	$12,312,000,000	$11,662,000,000	$11,028,000,000	$10,438,000,000
Gross production (volume)	$14,827,000,000	$15,986,000,000	$15,114,000,000	$15,242,000,000
Equilibrium product price (1959 prices = 1.00)	.71	.66	.62	.58
Per farm:				
Acres of land	1,048	1,106	1,170	1,236
Value of land and buildings[a]	$151,000	$159,000	$168,000	$178,000
Months of labor	14.8	14.8	14.8	14.8
Value of capital	$36,200	$36,200	36,200	$36,200
Gross production (total revenue)	$31,000	$31,000	$31,000	$31,000
Factor earnings	$16,200	$16,000	$16,000	$15,900
Factor opportunity costs	$16,200	$16,000	$16,000	$15,900
Residual to land capitalized into a value per acre	$102	$94	$89	$84

[a]Valued at observed 1959 land price.

Table 33. Characteristics of the minimum cost and market-clearing farm industry in 1980 with farm factors paid less than nonfarm factors, linear arithmetic demand function

	Farm factor opportunity cost rates as a percentage of nonfarm opportunity cost rates					
	100%	90%	80%	70%	60%	50%
For the North Central Region:						
Number of farms	322,100	325,600	329,200	332,700	335,400	339,000
Acres of land	356,350,000	356,350,000	356,350,000	356,350,000	356,350,000	356,350,000
Value of land and buildings[a]	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000	$51,315,000,000
Months of labor	4,767,000	4,820,000	4,872,000	4,926,000	4,964,000	5,017,000
Value of capital	$11,660,000,000	$11,790,000,000	$11,920,000,000	$12,050,000,000	$12,140,000,000	$12,270,000,000
Volume of production	$14,990,000,000	$15,110,000,000	$15,240,000,000	$15,370,000,000	$15,470,000,000	$15,590,000,000
Value of production	$9,890,000,000	$9,370,000,000	$8,840,000,000	$8,300,000,000	$7,890,000,000	$7,330,000,000
Equilibrium product price (1959 price = 1.00)	.65	.62	.58	.54	.51	.47
Per farm:						
Acres of land	1,106	1,094	1,083	1,071	1,062	1,051
Value of land and buildings[a]	$159,000	$158,000	$156,000	$154,000	$153,000	$151,000
Months of labor	14.8	14.8	14.8	14.8	14.8	14.8
Value of capital	$36,200	$36,200	$36,200	$36,200	$36,200	$36,200
Gross production (total revenue)	$30,700	$28,800	$26,900	$24,900	$23,500	$21,600
Factor earnings	$16,000	$14,100	$12,100	$10,200	$8,800	$6,900
Residual to land capitalized into a value per acre	$94	$90	$84	$78	$76	$67

[a]Valued at observed 1959 land price.

1959 observed situation and the 1959 and 1980 reorganizations are presented in the supplementary tables (22) for the 71 intrastate Census subregions included in the study. Subregions containing similar types of farming in adjacent states were combined by the Census into interstate subregions. Parts of 30 of these interstate subregions were included in the North Central Region.

Several relevant variables for interstate subregions are presented graphically in Figure 5 through Figure 12. In each figure, bar graphs indicating four values are included and are identified as A, B, C, and D. The bar A refers to the observed 1959 situation and bar B to the 1959 minimum cost and market-clearing situation. Bars C and D refer to the 1980 minimum cost and market-clearing situations under the condition that factor productivity increased at the annual compounded rates of 1.75 percent and 2.0 percent, respectively.

The direction and magnitude of changes are indicated by the bar graphs. In general, changes were fairly uniform among the interstate subregions. Variables illustrated include numbers of farms, months of labor input, value of capital input, and volume of production.

Since the review of literature did not reveal prior studies with strictly comparable objectives, the projections made in the present study could not be compared with other resource and production projections for 1980. However, the problem of optimum farm size had been considered in the present time setting in various studies made in the North Central region. Their results may be compared with the 1959 minimum cost and market-clearing situation as presented in Figures 5 and 6 concerning

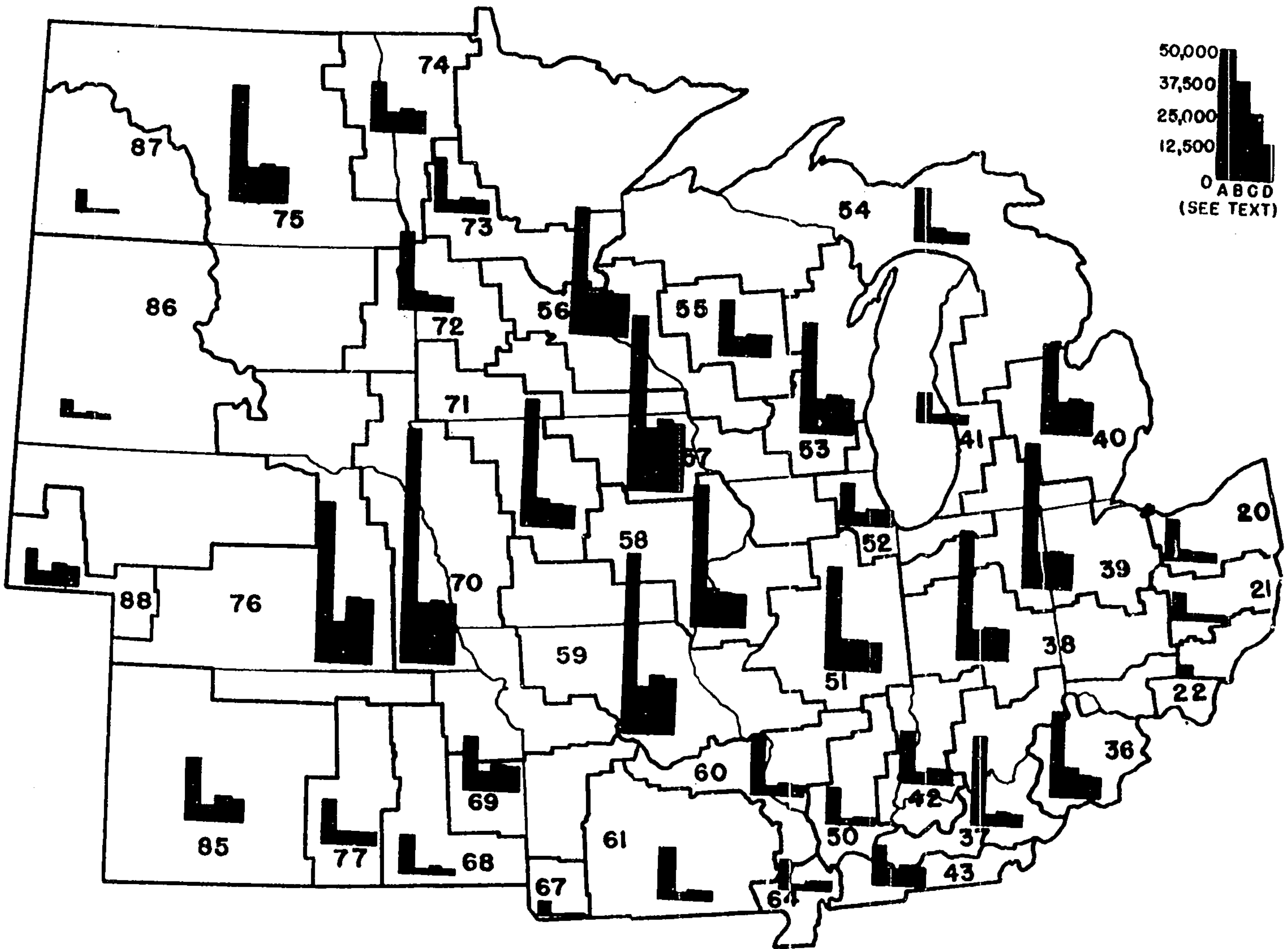

Figure 5. Number of commercial farms by interstate subregions under observed and optimal 1959 situations, and two 1980 projected situations

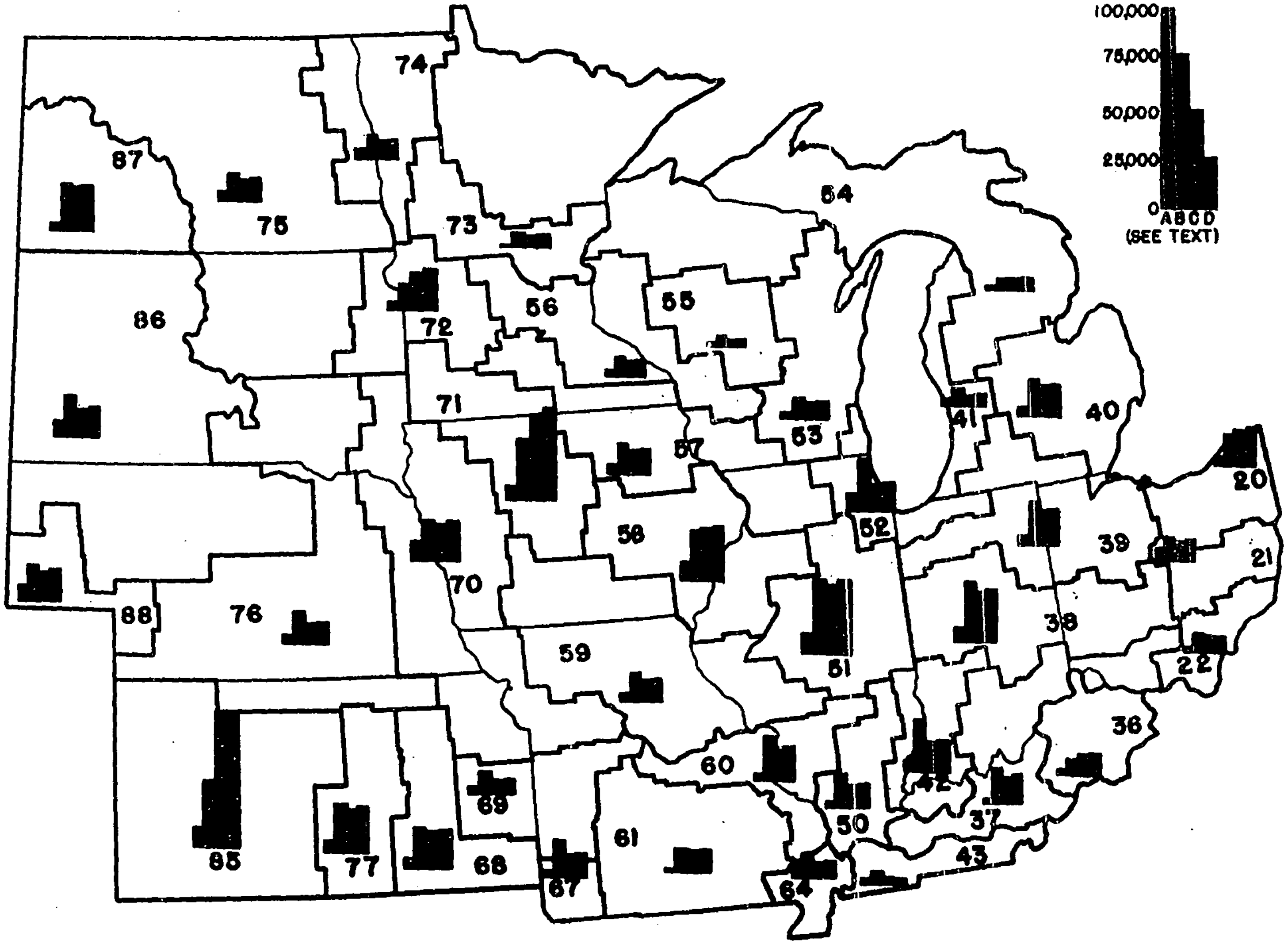

Figure 6. Value of land per farm by interstate subregions under observed and optimal 1959 situations, and two 1980 projected situations

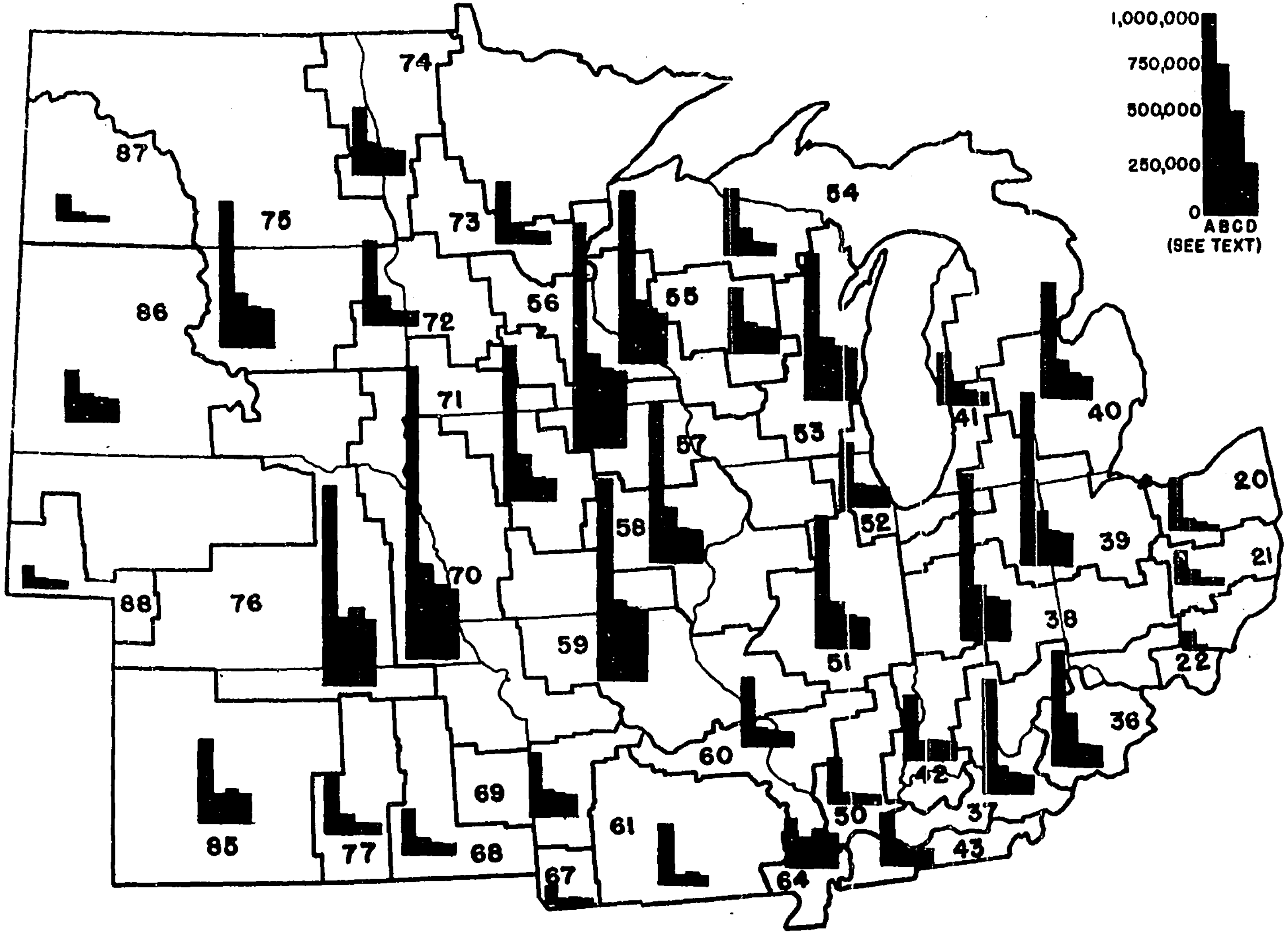

Figure 7. Months labor input per interstate subregion under observed and optimal 1959 situations, and two 1980 projected situations

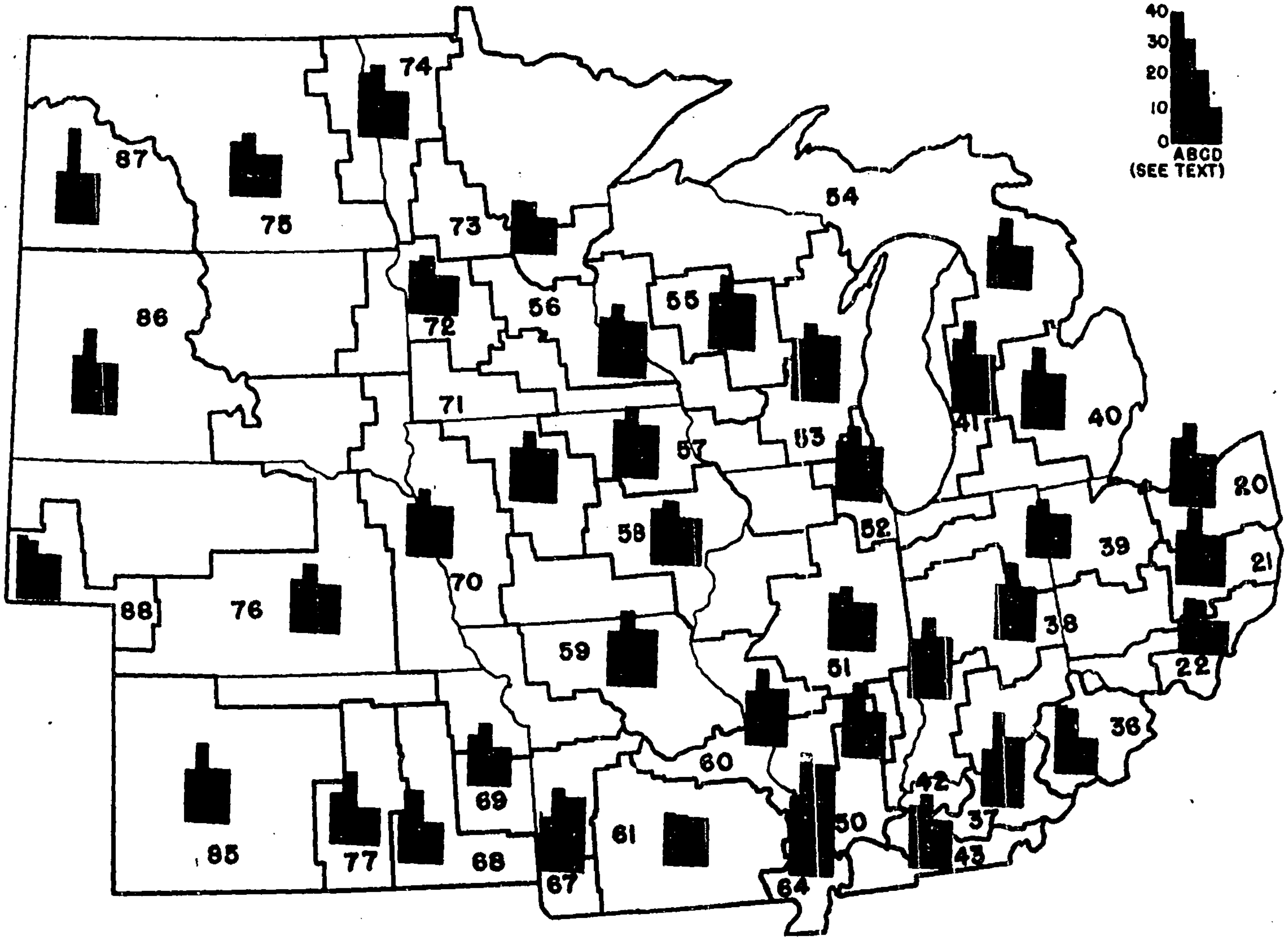

Figure 8. Months labor input per farm by interstate subregions under observed and optimal 1959 situations, and two 1980 projected situations

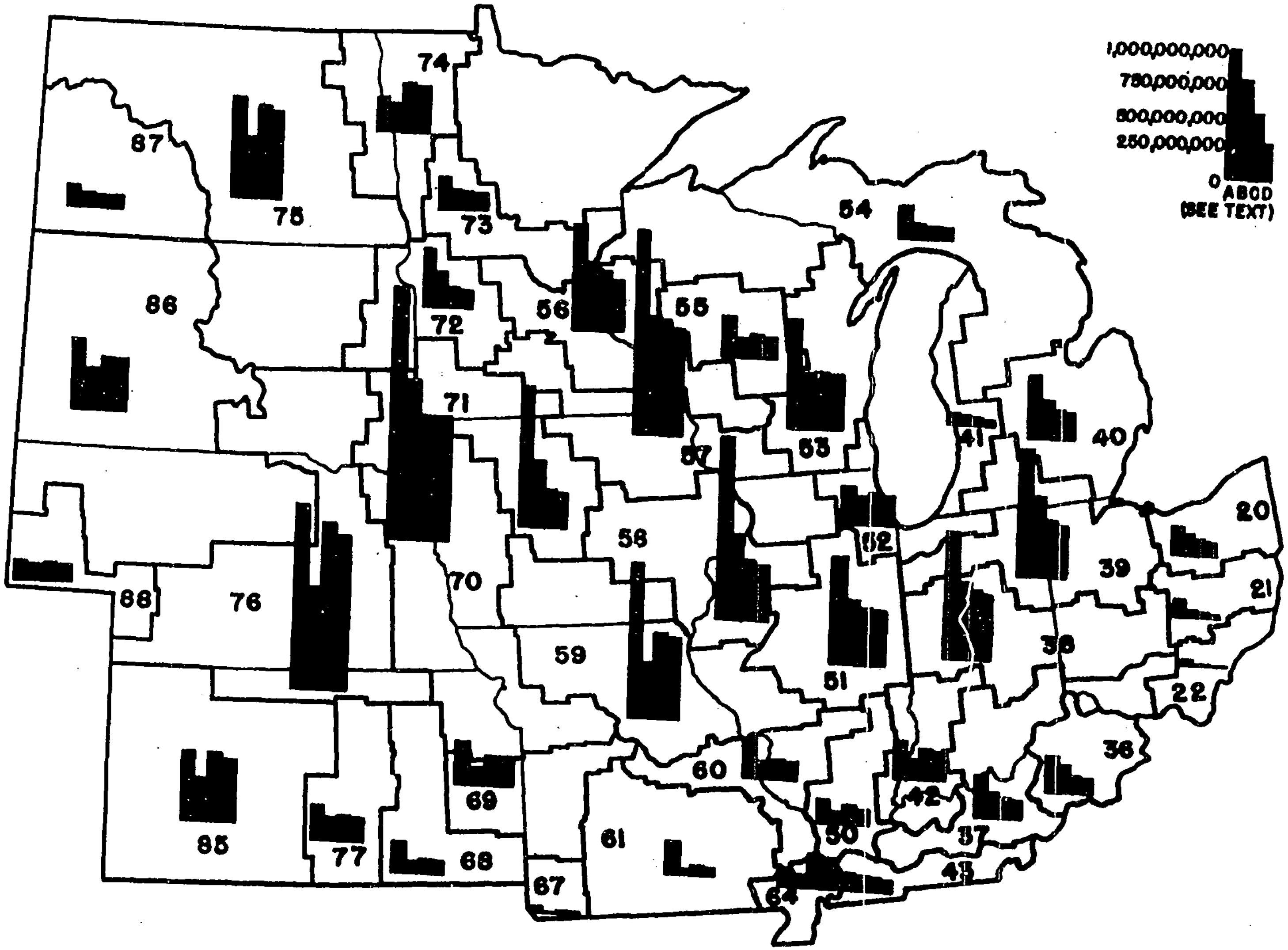

Figure 9. Value of capital input per interstate subregion under observed and optimal 1959 situations, and two 1980 projected situations

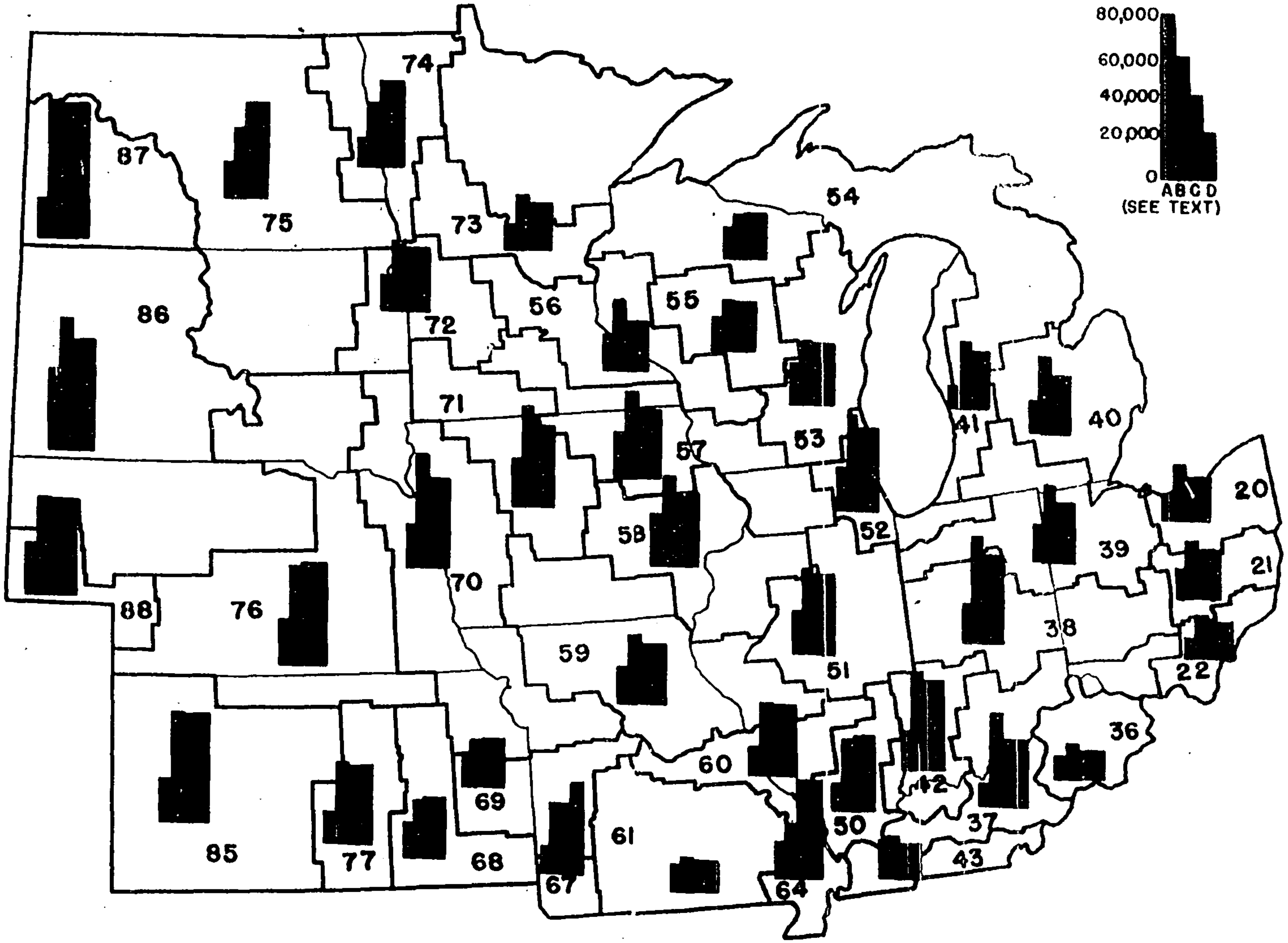

Figure 10. Capital input per farm by interstate subregions under observed and optimal 1959 situations, and two 1980 projected situations

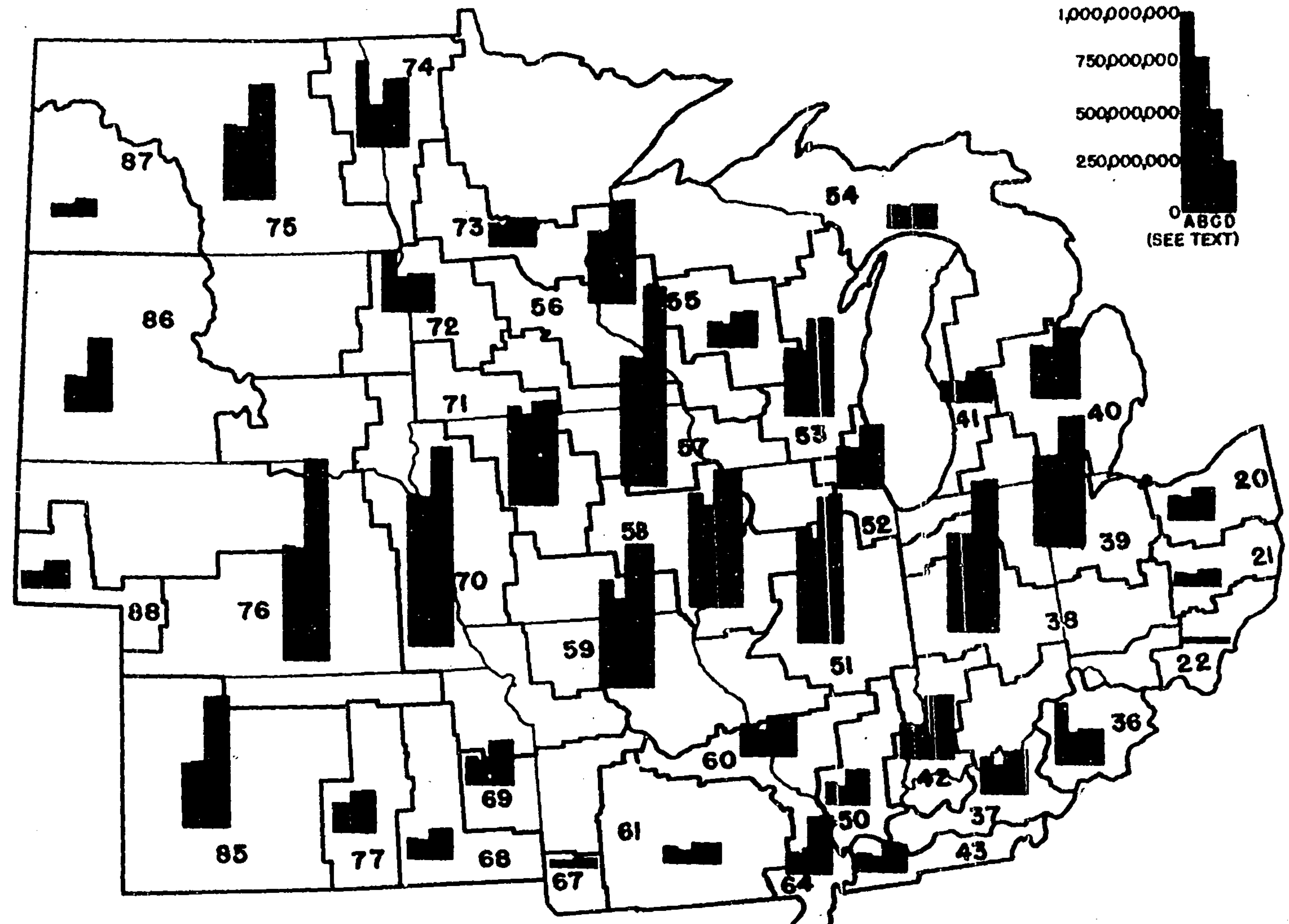

Figure 11. Gross production per interstate subregion under observed and optimal 1959 situations, and two 1980 projected situations

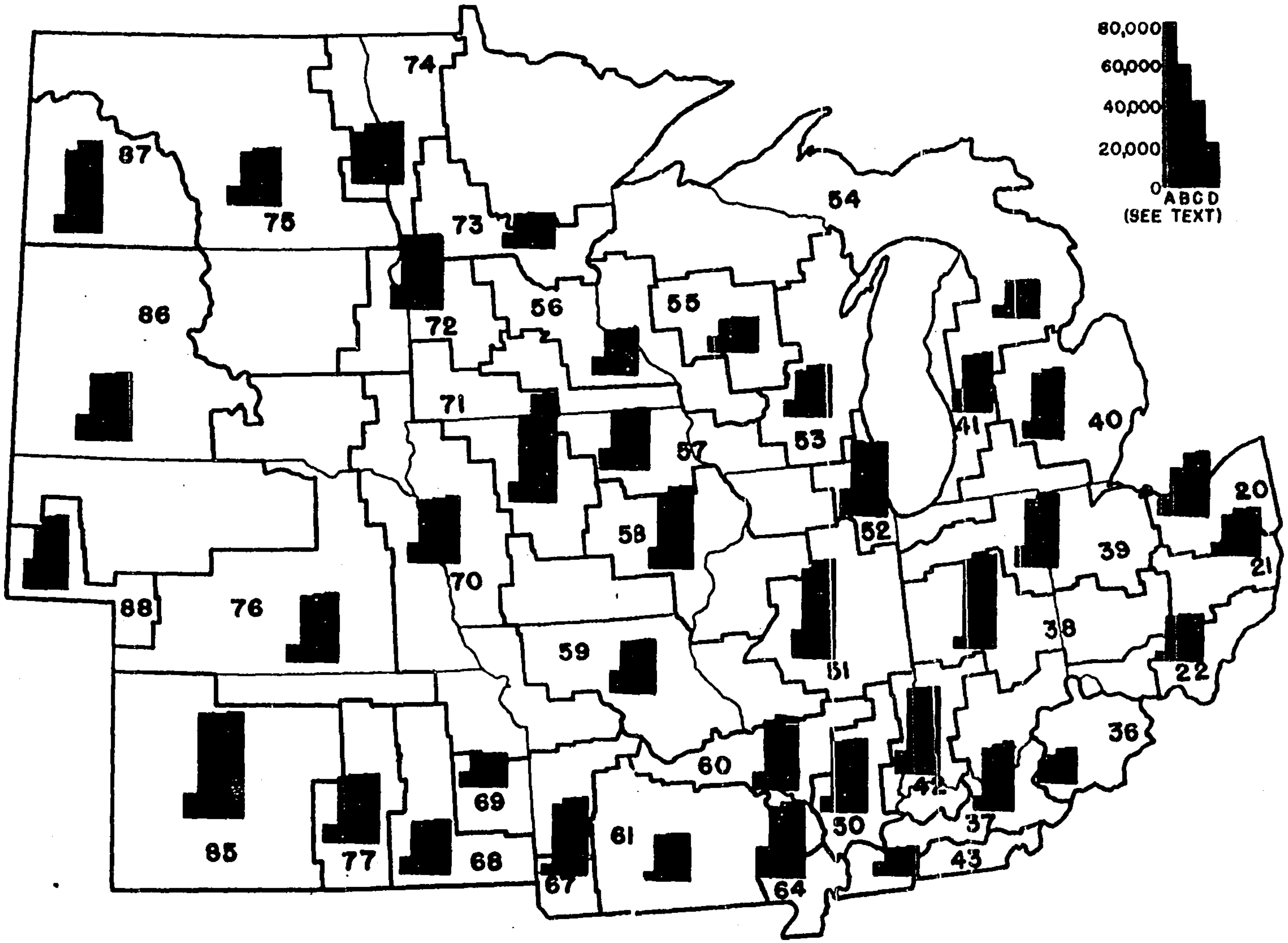

Figure 12. Gross production per farm by interstate subregions under observed and optimal 1959 situations, and two 1980 projected situations

numbers of farms and farm size, and are discussed in the following sections.

Red River Valley

In the Red River Valley area of Minnesota farm numbers declined 18 percent from 1950 to 1959, according to the Census of Agriculture. The numbers of farms over 500 acres or above increased while numbers in all other size groups decreased. Average size increased from 331 to 388 acres during that time. A 1963 study of the cost advantages of size (92) indicated that most advantages were realized when farms were from 700 to 1,100 crop acres, depending on the cropping system followed. However, the minimum point on the average cost per acre curve had not been reached at the 2,000 crop acre size.

These results are comparable with the present study which estimated optimal farm size to be 1,162 acres in Minnesota Subregion 1 and 1,213 acres in North Dakota Subregion 3, the areas corresponding to the Red River Valley.

Two Wisconsin Areas

In 1962, dairy farmers in South Central and Northwestern Wisconsin who had expanded their herds were interviewed concerning their experiences in the expansion of the dairy herd (93). Dairy herd size in Wisconsin was highly correlated with other measures of farm size.

The average size of dairy herds in these areas of Wisconsin had increased from 15 cows to 20 cows during the 1949 to 1959 decade. The survey indicated that average total farm costs per cow declined as numbers of cows had been increased on the farms studied, and had not reached a minimum at the 100 cow level. This was about five times the average herd size.

The areas included in the above study were parts of Wisconsin Subregions 1, 2, and 3. In the present study, farm size increased from 227 to 690 acres in Subregion 1, from 192 to 647 acres in Subregion 2, and from 213 to 570 acres in Subregion 3, in moving from the observed 1959 to the optimal 1959 situation. These represent sizeable increases in farm size measured in acres, although not as large as the changes in size measured in numbers of cows, suggested in the Wisconsin study.

Northeast Nebraska

A 1951 study in Northeastern Nebraska attempted to determine the differences between operating results when farms of various sizes were organized on a basis appropriate for each size of unit (94). Model farm size was 100-174 acres at the time of the study and average size had undergone little historic change at that time. The author indicated that for reasonably efficient utilization of machinery and equipment, farms in the area should have a minimum of 200 acres, and decreases in costs became relatively insignificant for units larger than 440 acres. However, the value of input per unit of output was reported to be lower for a 1,760 acre farm than for the 440 acre farm.

The latter finding was roughly comparable to the estimates made in the present study, where farms increased from 256 acres in the observed 1959 situation to 1,192 acres in the optimal 1959 reorganization in Nebraska Subregion 3. In the adjacent corner of South Dakota, farm size increased from 264 acres to 1,256 in those situations.

South Dakota

A study of 2,610 farm and ranch records in South Dakota in 1943 and 1944 were the basis for recommendations concerning the acres required to constitute an adequate family-type farm or ranch (95). In the western range area, the average size was 1,670 acres in 1945 and the recommended size was from 1,280 to 6,000 acres. In South Central South Dakota, observed size was about 600 acres and recommended size was 480 to 3,000 acres, depending on type of farm.

In the present study, farms in the western range area were included in South Dakota Subregion 1. They increased from 2,825 acres in 1959 to an estimated 8,196 acres in the optimal 1959 organization. This was somewhat larger than the recommended size in 1945 for that area.

South Central South Dakota fell into Subregion 3 in the present study. Observed mean size was 529 acres in 1959, and the estimated optimal size was 2,498 acres in 1959, comparable with the 1945 recommendations.

A 1960 budgeting study for wheat farmers in North Central South Dakota (96) indicated that a 1,280 acre farm had possibilities for more efficient use of machinery and equipment and savings in labor, compared with 480 and 880 acres farms. Average farm size was 580 acres at the time of the study.

The area in the above budgeting study was a part of South Dakota Subregion 2 in the present study. The differences in geographical areas included were reflected in the differences in average farm size, which was 830 acres in the Census Subregion in 1959 and 580 acres in the region studied in 1960. In the present study, optimal farms in 1959 contained about three times the observed 1959 acreage, or 2,440 acres compared to 839 acres.

The above studies indicate that the minimum cost sizes of farms in these locations were considerably larger than those observed when the studies were made. Direction and magnitude of change was similar to the changes indicated by the 1959 minimum cost and market-clearing reorganization in the present study.

Limitations of the Study

It is important that the reader consider the estimates and projections made in the present study only in light of the purpose for which they were developed, the assumptions underlying them, and the sources of data. These were generally identified throughout the thesis. In several cases, alternative sets of estimates or projections were made where an *a priori* basis for a unique value was lacking. For example, four projected rates of increase in factor productivity were explored.

The author had an additional responsibility in indicating possible limitations to the study which might not be apparent to the reader. Other limitations to the study may have escaped his attention but be apparent to the reader. The more important known limitations are discussed in the following sections.

Product mix

There may be a limitation in the theoretical construct of the present study since the problem of product mix was not considered. It was indicated previously that the farm industry has a greater internal capacity to deal with this type of problem than with imbalances in resource cost or level of industry production. It was thus considered to be a problem of less importance.

It was also indicated that as the ratio of capital plus labor inputs per unit of land was decreased in reducing total volume of output, that a change in product mix was likely to occur. Thus, intensive livestock or cropping systems would give way to more extensively organized activities. This seemed to be a reasonable hypothesis.

However, the problem was complicated by relative product prices being implicitly held at their base period relationships. Beef cattle and hog prices were adjusted to their cyclical mean levels, but other product prices held the same relationships to each other as had existed in 1959. Had the price of some major product deviated more widely from its long-run equilibrium price than other product prices, then some distortion may have entered the study.

The distortion would occur in an intrastate subregion if the product whose price was out of line was the only major production activity in that area. For a hypothetical example, wheat might have been priced "high" relative to a more extensively organized production activity competitive with it for resources, such as beef cow herds. Under those hypothetical conditions, a subregion specializing in wheat production but suitable for beef cow herds should have experienced more reorganization and extensification than took place in the present study. The magnitude of the adjustments would have been understated in the estimates and projections included in the present study.

The extent to which this hypothetical situation may have existed in reality in the Great Plains states included in the present study was not known.

<u>Product demand</u>

Two alternatives concerning the demand schedule for farm products in 1959 and 1980 were explored in the present study. Sets of estimates and projections were made for a demand schedule that was arithmetically linear and for a schedule with constant price elasticity (linear in logarithms). A third alternative, elasticity being an increasing absolute negative value as farm product prices fell, was not included. Although there may have been intuitive basis for including this kind of a function, there was little empirical basis for establishing a projected value for elasticity in the 1980 situation.

<u>Sources of 1959 data</u>

The 1959 Census of Agriculture was the major source of data in making the estimates concerning the observed situation in the farming industry in 1959. They were supplemented with some USDA and farm record data, particularly in estimating farm operating expenses and value of machinery. If the adjustments made to the various data to make them comparable were not adequate, then the estimates presented in the study may not reflect the true situation in the farm industry in 1959.

Well-organized farms

Data from individual farm records were examined and those farms with the largest positive excess of factor earnings over factor opportunity costs (or least negative residual) were selected to represent farms approximating the economic efficiency conditions. The professional supervision given the farm operators in their accounting efforts was generally adequate to insure over-all reliability of the farm record data. However, farm record data from areas that lacked supervision might have lacked reliability. Also, only a few farm records were available from some intrastate subregions, which would be a limitation on this source of data. Additionally, there was no assurance that the farms with the largest excess of factor earnings over factor opportunity costs had been included in the record keeping groups.

Even if all the above possible limitations had in fact existed, however, it could still be asserted that the farm record data were generally reliable, and that they reflected the characteristics of farms that were better organized than the average farm.

Extensification regression

An extensification regression was developed from farm record data in most intrastate subregions, but where numbers of farms were lacking, interstate data were used. Generally, the data fit linear functions well, but since the regression equation could be interpreted to be a production function, it would have been untenable to assume that the linearity could be extrapolated indefinitely beyond the range of observations. In some subregions it was necessary, however, to extrapolate beyond the range of experience toward the origin, which could have raised questions concerning the realism of the farms so defined if there had not been more extensive types of farming alternatives for that area.

Resource characteristics in 1980

The proportions of non-land inputs on well-organized farms in 1980 were projected by extrapolating the changes in input mix that had taken place on all farms in the base period. Insofar as the changes in prices and technology that caused shifting among inputs on all farms in the base periods would not cause similar shifting among inputs on well-organized farms between the base period and 1980, the non-land resource mix projected for 1980 farms would contain an element of error. A set of projections for each of four rates of increase in factor productivity were made, selected from the range of values that appeared reasonable after observing trends in the base period. There was no empirical basis for selecting one rate as the true rate.

Observed land price

It was assumed that the observed price of land per acre in 1959 adequately reflected differentials in productivity, and that a dollar's worth of land was homogeneous in respect to its ability to produce. Input of land was measured in value terms throughout the analysis.

Since the unit of land in the analysis was basically one dollar's worth of land, the marginal physical product and marginal value product per acre were directly related to the observed price of land per acre in 1959. The equilibrium product price in each subregion in the 1980 projections was determined by equating the capitalized marginal value product of land per acre with the capitalized residual per acre derived when nonland factors were paid their opportunity costs. Thus, equilibrium product price reflected observed land price per acre, and if observed land price did not accurately measure land productivity, there would be inconsistencies generated between subregions.

This may be a partial explanation of why equilibrium product price varied among the 71 intrastate subregions. Additionally, it was implicitly assumed that the opportunity cost rates for nonland inputs approximated their marginal value products. Any deviations in reality from this assumption would be reflected in the residual allocated to land, and thus affect the equilibrium product price. Thus, there were opportunities for the equilibrium product price in the individual subregions to contain a component of error. This tended to limit the precision of the projections on a subregion basis and would suggest that relatively small differences among the subregions in characteristics might be more apparent than real.

SUMMARY

Summary of the Preceding

This chapter is included to facilitate the use of the thesis by the reader. For a person reviewing the literature it should be helpful in indicating which parts, if any, might be of use if pursued further and it also provides a comprehensive outline of the thesis. The summary contains only a restatement of what has been discussed in the preceding chapters.

The problem

The problem in this study was to estimate for 1959 and project for 1980 the resource and production characteristics of the farm industry in the North Central Region of the United States, under the condition that specified requirements for economic efficiency would be satisfied. The efficient organization of the farm industry would require the satisfaction of three conditions:

a. farm output be produced at minimum factor cost,

b. aggregate farm output clear the market at prices covering the opportunity cost of the factors,

c. the product mix be geared to the relative demands for different products.

Meeting these requirements would mean that the income of the individual farm operators would be maximized, and the farm industry would make its maximum contribution to national income.

Relevancy of the problem

Implicit in attacking this problem was the hypothesis that existing resource and production characteristics of the farm industry were not approximations to the economic efficiency conditions. It was specifically hypothesized that the farming industry contained two serious types of resource imbalances:

a. imbalance in resource cost,

b. imbalance in the level of farm production.

The product mix problem was not considered in the present study. The farm industry had greater internal capacity to deal with this type of problem, and it was considered to be a problem of less importance.

Uses for the estimates and projections

The present study was a part of the North Central Regional Project NC-53 concerning needed adjustments in land tenure. The resource and production characteristics of the efficiently organized farm industry that were estimated and projected in the present study were to be used as guides for determining needed changes in agricultural institutions. In succeeding phases of the NC-53 project the assumption of income maximization as the exclusive goal of farm operators was to be modified to allow consideration of non-income goals of farm operators.

Besides the immediate use as bench marks in further research, there are other possible uses for the estimates and projections. The projections specify the conditions under which the two major resource imbalances in agriculture would be corrected. Economic efficiency in resource cost and level of production would prevail in the farm industry under the conditions specified by the estimates and projections, and that part of the current "farm problem" reflected in those imbalances would essentially be solved. The projections might thus be of interest to legislators, organizations that represent the interests of farmers, and formulators of agricultural policy and farm legislation.

The estimates and projections would also contain implications for person involved in farm credit, farm tenure, rural institutions and agricultural education.

Assumptions

Three major assumptions underpin the estimates and projections:

a. all resource owners were strict income maximizers,

b. each farm firm bought and sold in markets so large that his activities had no effect on prices,

c. the quantities of capital and labor used by the farm industry were drawn from a market so large that the farm industry demand had no effect on prices (the supplies of labor and capital were perfectly elastic to the farm industry).

The assumption that income maximization was the exclusive objective of farm operators was relaxed at a later stage in the analysis. It was an appropriate assumption for the initial approximation, however, since a high level of intensity of desire for income must be among the goals of a farm operator if he is to continue in business over time.

Exogenous variables in the problem

The values of certain variables were considered to be known in solving the problem. These values were empirically estimated but once obtained were exogenous in the solution of the problem. They included:

a. the opportunity cost rates (prices) for capital, and labor,

b. the quantity of farm land available to the farm industry,

c. the demand function for farm products

Endogenous variables in the problem

The value of each of the following endogenous variables was determined under the conditions specified in the study:

a. the quantity of land per farm,

b. the quantity of labor per farm,

c. the quantity of capital per farm,

d. the quantity of production per farm,

e. the value of land per acre,

f. the level of farm product prices,

g. the number of farms.

Observed characteristics of the farm industry in 1959

The estimates and projections of the resource and production characteristics of the farm industry in 1959 and 1980 were made in a series of steps. The first step was to identify the characteristics of the farm industry as it existed in each subregion in 1959. These characteristics were used to identify the existence and magnitudes of resource imbalances and as bench marks in measuring changes in the farm industry as the imbalances were adjusted.

The characteristics were developed mainly from 1959 Census of Agriculture data supplemented by USDA sources and farm record keeping association summaries. The input totals for labor, capital, and land and the total production were estimated for each subregion. The number of farms in each subregion was known and per farm characteristics were calculated as mean values from the subregion totals. Additionally, gross production per farm, factor earnings, and factor opportunity costs per farm were estimated. These estimates for the aggregated North Central Region were included in Table 28, in the immediately preceding chapter on results.

Minimum cost reorganization of farms in 1959

The second major step in the project was to identify and select well-organized farms in each subregion for 1959 and reorganize the land base in the subregion into farms with the mean characteristics of the well-organized units. In the present study, farms were considered to be well-organized if they had a relatively high factor earnings to factor opportunity costs ratio.

Well-organized farms were identified from data in individual farm records kept by farmers participating in the farm record keeping organizations in each state. The observed data in the individual farm records were adjusted to account for the effect of abnormal weather on crop production and for variations from cyclical mean prices for hogs and cattle. Additional adjustments were made in factor opportunity cost rates to insure consistency in the differentials among subregions.

The group of well-organized farms was identified as those farms with the greatest positive (or least negative) excess of factor earnings over factor opportunity costs. It was assumed that each of the farmers included in this selected group had organized his farm business so that he was approximating the conditions for efficient organization of the firm under market and technological conditions existing at that time.

The mean resource and production characteristics of the selected group of farms were estimated. The mean value of land per farm was used to divide the total value of land in the subregion into farms, each of which assumed the characteristics of well-organized farms. Subregion totals were then calculated for the resource and production characteristics.

The selected well-organized farms in 1959 had a substantially larger land base than the observed farms in 1959. For the aggregated North Central Region, value of land and buildings per farm was 64 percent larger after the minimum cost reorganization than in the observed situation. With a fixed land base, this resulted in a reduction in the number of farms by 39 percent.

For the aggregated North Central Region, input of labor was reduced 21 percent while input of capital was increased 32 percent. An increase in gross production of 93 percent resulted. The total cost of factors declined from $11.04 billion to $10.94 billion while gross production increased from $10.27 billion to $20.39 billion. This suggested that an imbalance in resource cost existed in 1959 (the output of the region was not being produced at minimum factor cost).

<u>Reorganization of the industry to the market-clearing level of production in 1959</u>

The minimum cost reorganization described in the preceding section generated a situation in which all farms were organized at the minimum cost level of output. Total farm industry production was not necessarily equated with demand at the observed price level, however. In fact, total production was nearly double the observed level of output in 1959, which had exceeded the quantity that would have cleared markets at observed prices.

The purpose of the second, marketing-clearing reorganization was to equate each subregion's total production with its share of market-clearing demand in 1959, within the framework of well-organized farms.

Each subregion's share of the market-clearing level of demand in 1959 was estimated. The second reorganization involved changing the resource structure of farming by decreasing the input of capital and labor per unit of land until total production dropped to the desired market-clearing levels. The device for carrying out this extensification was a set of regression equations developed from data on well-organized farms in each subregion. The regression used the input of capital and labor per unit of land as the independent variable regressed against gross production per unit of land as the dependent variable.

Given the subregion's share of total demand for farm production and the quantity of land in the subregion, the required level of production per unit of land was determined. The reduction of capital and labor input per unit of land was carried out through the regression equation until the desired production per unit of land was reached. This was the level at which total production for the subregion would just equal the subregion's share of total demand for farm production.

The endogenous variables solved for in the market-clearing reorganization were the same variables that were specified by the first reorganization. In addition, the residual earnings of land after labor and capital had been awarded their opportunity costs were capitalized into a land value per acre. The equilibrium product price level was estimated by setting the residual capitalized value of land equal to the marginal value product of land. The price level at which this phenomenon occurred was defined as the equilibrium market-clearing price level.

The extensification of farming to reduce gross production per unit of land took place within the group of farms previously identified as being well-organized. Thus, the structure of farms after the second reorganization still approximated the minimum-cost criterion, as well as the industry meeting the market-clearing conditions, at prices covering the opportunity costs of factors.

After the minimum cost and market-clearing reorganizations in 1959, the number of farms in the North Central Region was about one-fourth the number in the observed 1959 situation. Acres per farm increased from 315 to 1,200 acres, labor per farm increased from about 16 to 21 months, and the value of capital increased from about $18,000 to about $40,000 per farm. Output per farm increased from about $9,000 to about $30,000.

For the entire North Central Region, the land base was unchanged, labor input declined by about two-thirds, and capital input by about 45 percent. Total production declined 11 percent to bring aggregated production into line with the estimated share of demand for the region.

Land value per acre declined from $144 to just under $100. The combined investment in land and capital per farm increased from $63,000 to $212,000, from the observed 1959 situation to the minimum cost and market-clearing reorganization in 1959.

Minimum cost and market-clearing reorganization in 1980

In the preceding sections the procedure by which the minimum cost and market-clearing level of production for 1959 was estimated was described briefly. The same basic procedure was used to arrive at projections for 1980. However, several data and exogenous variables which were given or were readily ascertained in the 1959 model had to be projected for the 1980 model.

The factors of production, particularly capital and labor, had apparently become more productive per unit of input in the years preceding this study. It was assumed that capital and labor would continue to increase in productivity during the 1959-1980 period. Four rates of increase in factor productivity were selected and a set of solutions for 1980 calculated for each.

The resource mix used in farming had also undergone change in the years preceding the present study. The direction and magnitude of these changes were determined and estimates made as to the probable farm resource mix in 1980.

In the present model the opportunity cost rates for capital in the form of farm real estate, for other capital, and for labor were considered to be generated by the nonfarm industry. The directions and magnitudes of changes in these rates in the past were determined and estimates made for their values in 1980.

The projected 1980 demand for farm production was based on the 1959 market-clearing quantities, using estimated changes in population, income per capita, and export demand as the demand shifters. Total estimated 1980 demand for farm production was allocated among subregions on the basis of the evaluated trend in their share of total United States farm production.

The quantity of farm land which would be removed from the supply of land for nonfarm use during the 1959-1980 period was estimated. It was assumed that the nonfarm sources of demand for land were price inelastic and when they were filled the supply of land to the farming industry was fixed.

Once estimated, the above variables were considered exogenous to the problem, and the values of the endogenous variables were calculated as in the 1959 second reorganization. The residual to land was capitalized into a value per acre and equated with the marginal value product of land. This determined the equilibrium solution to the problem.

In the 1980 projections that met the specified efficiency conditions, farms were organized at their minimum cost level of production. Additionally, capital and labor earned their opportunity costs, the residual capitalized into a land value equaled the marginal value product of land,

and the total industry production cleared the market at the indicated price level.

A unique solution was calculated for each of the four rates of increase in factor productivity projected for 1980, and for a series of situations in which farm factors earned less than their non-farm opportunity costs.

The major adjustments made in moving from the observed 1959 situation to the minimum cost and market-clearing situation in 1980 were made in correcting the imbalances in resource cost and level of farm production that existed in 1959. The characteristics of the farm industry in equilibrium in 1959 were very similar to the industry in equilibrium in 1980, with the exception that the per farm labor input was much lower in 1980.

The number of commercial farms exceeded 1.1 million in the observed 1959 situation and about .3 million in the 1980 efficiency projections. This could be accomplished by an annual absolute decline in farms equal to the observed annual decline during the 1949-59 period.

The required decline in input of all farm labor to meet the 1980 efficiency conditions would require a constant annual percentage decrease equal to that observed in the 1939-59 period. A decline in the value of capital input from $21.6 billion in the observed 1959 situation to about $12.0 billion would be necessary to meet the projected efficiency conditions in 1959 and in 1980.

The farm industry characteristics in the 1980 efficiency situations were generally similar under the four projected rates of factor productivity increase. Numbers of farms ranged from 346,300 under a 1.5 percent rate of increase down to 300,700 under a 2.25 percent increase. The higher the rate of factor productivity increase, the lower the ratio of capital plus labor input per unit of land, and the lower the prices of farm products and farm land.

When farm factors were paid less than their nonfarm opportunity cost rates it was observed that accepting the lower rate of return did not increase farming opportunities appreciably. Additionally, a relatively small increase in total production, generated by lower factor costs, resulted in sizeable decreases in product prices and factor earnings per farm.

LITERATURE CITED

1. Brown, Dean and Raymond R. Beneke. Farm consolidation in Iowa. Iowa Farm Science 12, No. 11: 3-5. 1958.

2. Hoffman, Randall A. and Earl O. Heady. Production, income, and resource changes from farm consolidation. Iowa Agricultural and Home Economics Experiment Station Research Bulletin 502. 1962.

3. Howell, H. B. and E. Stoneberg. East-central Iowa farm business summary, 1962. Iowa State University of Science and Technology Cooperative Extension Service Farm Management Bulletin FM-1432. 1963.

4. Mueller, A. G. Summary of Illinois farm business records, 1962. University of Illinois Cooperative Extension Service Circular 874. 1963.

5. Trautwein, Marvin W. Differential rates of resource adjustment within Iowa agriculture, 1940 to 1954. Unpublished M.S. thesis. Ames, Iowa. Library, Iowa State University of Science and Technology. 1958.

6. Kaldor, Donald R., Raymond R. Beneke, and Russell W. Bryant. Comparison of resource returns of well-organized farms with selected non-farm opportunities. Iowa Agricultural and Home Economics Experiment Station Research Bulletin 491. 1961.

7. U.S. Department of Agriculture. Agricultural Statistics, 1962. 1963.

8. U.S. Department of Agriculture. Agricultural Stabilization and Conservation Service. 1963 feed grain program, statistical summary. Washington, D.C. Author. 1964.

9. ________. 1963 wheat stabilization program, statistical summary. Washington D.C. Author. 1964.

10. U.S. Department of Agriculture. Economic Research Service. Foreign agricultural trade of the United States. Washington, D.C. 1964.

11. U.S. Department of Agriculture. Agricultural Stabilization and Conservation Service. Charts providing a graphic summary of CCC operations. Washington, D.C. Author. 1963.

12. Craft, Rolf V. A projection of an efficient farm industry in Southern Iowa 1959, 1980. Unpublished M.S. thesis. Ames, Iowa. Library, Iowa State University of Science and Technology. 1965.

13. Varley, A. P. and G. S. Tolley. Simultaneous target planning for farms and the area. Journal of Farm Economics 44: 979-991. 1962.

14. Langvatn, Harry. Evaluation of the agricultural adjustment problem in Norwegian agriculture by linear programming (Translated title). Unpublished manuscript. Oslo, Norway, Norges Landbruksokonomiske Institutt. 1963. Original not available; translation provided by Harry Langvatn, Norges Landbruksokonomiske Institutt, Oslo, Norway. 1963.

15. Egbert, Alvin C. Programming regional adjustments in resource use for grain production. Unpublished Ph.D. thesis. Ames, Iowa. Library, Iowa State University of Science and Technology. 1958.

16. Whittlesey, Norman K. Linear programming models applied to interregional competition and policy choices for U. S. agriculture. Unpublished Ph.D. thesis. Ames, Iowa. Library, Iowa State University of Science and Technology. 1964.

17. U.S. Dept. of Agriculture. Equilibrium analysis of income improving adjustments on farms in the Lakes States Dairy Region, 1965. Minnesota Agricultural Experiment Station Technical Bulletin 246. 1963.

18. Reder, Melvin W. Studies in the theory of welfare economics. New York, N.Y., Columbia University Press. 1947.

19. Tintner, Gerhard and O. H. Brownlee. Production functions derived from farm records. Journal of Farm Economics 26: 566-571. 1944.

20. Heady, Earl O. Production functions from a random sample of farms. Journal of Farm Economics 28: 989-1004. 1946.

21. Ezekiel, M. and Karl A. Fox. Methods of correlation and regression analysis. 3rd ed. New York, N.Y., John Wiley and Sons, Inc. 1959.

22. Kaldor, Donald R. and William E. Saupe. Supplementary tables for NC-53 committee report. Mimeographed. Ames, Iowa, Department of Economics, Iowa State University of Science and Technology. 1965.

23. U.S. Census Bureau. Worksheets for State Table 17 [for U.S. Census of Agriculture, 1959]. Washington, D.C. Author. 1960.

24. U.S. Dept. of Agriculture. Agricultural prices annual summary, 1961. Washington, D.C. 1962.

25. Kansas State Board of Agriculture. Statistical Division. Farm facts 1956 through 1961. Topeka, Kansas. Author. 1962.

26. Minnesota Department of Agriculture. Statistical Reporting Service. Minnesota [Annual] Agricultural Statistics. 1956 - 1960.

27. Purdue University. Department of Agricultural Statistics. Indiana Crops and Livestock Annual Summary, 1962. 1963.

28. Nebraska Department of Agriculture and Inspection. Division of Agricultural Statistics. Nebraska Agricultural Statistics. 1956 - 1959.

29. North Dakota State University. Statistical Reporting Service. Crop and Livestock Statistics, 1962. 1963.

30. South Dakota Department of Agriculture. South Dakota Crop and Livestock Reporting Service. South Dakota Agricultural Statistics, 1961. 1962.

31. Iowa Department of Agriculture. Statistical Reporting Service. Annual Farm Census, 1962. 1963.

32. Illinois Department of Agriculture. Illinois Cooperative Crop Reporting Service. Illinois Agricultural Statistics Annual Summary, 1962. 1963.

33. Michigan Department of Agriculture. Michigan Agricultural Statistics, 1963. 1964.

34. Wisconsin State Department of Agriculture. Statistical Reporting Service. Wisconsin Crop Summary. 1955 - 1960.

35. Ohio Agricultural Experiment Station. Statistical Reporting Service. Ohio Agricultural Statistics Annual Report, 1963. 1964.

36. Missouri State Department of Agriculture. Missouri farm census by counties. 1957 - 1961.

37. Kentucky Department of Agriculture. Kentucky Crop and Livestock Reporting Service. Kentucky Agricultural Statistics, 1962. 1963.

38. U.S. Dept. of Agriculture. Field and seed crops-production, farm use, sales, value. U.S. Department of Agriculture Statistical Reporting Service Bulletin 311. 1962.

39. ________. Crop production annual summaries. 1960 - 1963.

40. ________. Field crops by states, 1949-54. U.S. Department of Agriculture Statistical Reporting Service Bulletin 185. 1956.

41. ________. Field crops by states, 1954-59. U.S. Department of Agriculture Statistical Reporting Service Bulletin 290. 1961.

42. ________. Sorghums by states, 1929-58. U.S. Department of Agriculture Statistical Reporting Service Bulletin 320. 1962.

43. ________. Barley by states, 1866-1953. U.S. Department of Agriculture Statistical Reporting Service Bulletin 241. 1959.

44. ________. Wheat by states, 1866-1943. U.S. Department of Agriculture Statistical Reporting Service Bulletin 158. 1955.

45. ________. Hay by states, 1866-1953. U.S. Department of Agriculture Statistical Reporting Service Bulletin 229. 1958.

46. ________. Cotton by states, 1866-1958. U.S. Department of Agriculture Statistical Reporting Service. 1960.

47. ________. Measuring the effects of weather on agricultural output. U.S. Department of Agriculture Economic Research Service Bulletin ERS-72. 1962.

48. Auer, Ludwig. Impact of crop yield technology on United States crop production. Unpublished Ph.D. thesis. Ames, Iowa. Library, Iowa State University of Science and Technology. 1963.

49. Thompson, Louis M. Weather and corn production. Iowa State University of Science and Technology Center for Agricultural and Economic Adjustment Report 12. 1962.

50. ________. Weather and technology in the production of corn and soybeans. Iowa State University of Science and Technology Center for Agricultural and Economic Adjustment Report 17. 1963.

51. Dale, Robert F. Changes in moisture stress days since 1933. Iowa State University of Science and Technology Center for Agricultural and Economic Adjustment Report 20: 23-44. 1964.

52. U.S. Dept. of Agriculture. Livestock-feed relationships, 1909-1963. Washington, D.C. U.S. Department of Agriculture Economic Research Service Bulletin 337. 1963.

53. ________. Prices received by farmers for hogs. U.S. Department of Agriculture Agriculture Marketing Service Bulletin 257. 1964.

54. Brandow, G. E. Interrelations among demands for farm products and implications for control of market supply. Pennsylvania Agricultural Experiment Station Bulletin 680. 1961.

55. Livestock marketing in the North Central Region. Ohio Agricultural Experiment Station Research Bulletin 846. 1959.

56. U.S. Dept. of Agr. State estimates of farm income, 1949-62. U.S. Department of Agriculture Economic Research Service [Publication] FIS-191 Supplement. 1963.

57. U.S. Census Bureau. Census of Agriculture, 1959. Vol. 1. County Reports. 1960.

58. U.S. Dept. of Agr. Cattle and calves on feed, selected states by quarters, 1955-59. U.S. Department of Agriculture Agricultural Marketing Service Bulletin 277. 1961.

59. ________. The pig crop: Agricultural Marketing Service statistical bulletin. Washington, D.C. Author. 1961.

60. U.S. Census Bureau. Farmers and farm production in the United States: special report [from U.S. Census of Agriculture, 1954]. Washington, D.C. Author. 1956.

61. U.S. Dept. of Agriculture. Area variations in wages of agricultural labor in the United States. U.S. Department of Agriculture Technical Bulletin 1177. 1958.

62. Agricultural finance review. Vol. 24. 1963.

63. ________. Farm real estate market developments. U.S. Department of Agriculture Economic Research Service Publication CD-64. 1963.

64. Federal Reserve Bulletin 48. No. 1. 1962.

65. U.S. Dept. of Agr. Economic Research Service. Farm mortgages recorded in 1959: interest rates, terms, and sizes with historic data, 1949-59. Washington, D.C. Author. 1961.

66. United States Farm Credit Administration. 27th annual report. 1960.

68. U. S. Census Bureau. General social and economic characteristics, U.S. summary: Final Report PC1-IC [from U.S. 18th Census, 1960]. Washington, D.C. Author. 1962.

69. Miller, Frank and Ronald Bird. Profitable adjustments on farms in the Eastern Ozarks of Missouri. Missouri Agricultural Experiment Station Research Bulletin 745. 1960.

70. Pond, G. A. Farm accounts as a source of data for farm management research. Minnesota Agricultural Experiment Station Technical Bulletin 219. 1956.

71. U.S. Department of Agriculture. Measuring the supply and utilization of farm commodities, 1959 supplement. Washington, D.C. Agricultural Marketing Service, U.S. Department of Agriculture. 1960.

72. ________. Measuring the supply and utilization of farm commodities. U.S. Department of Agriculture Agricultural Marketing Service Handbook 91. 1955.

73. Schultz, Theodore W. Value of United States farm surpluses to underdeveloped countries. Journal of Farm Economics 42: 1019-1030. 1960.

74. Tyner, Fred H. and Luther G. Tweeten. Excess capacity in United States agriculture. Agricultural Economics Research 16: 23-31. 1964.

75. Rudd, R. W., chairman. Policy for United States agricultural export surplus disposal. Arizona Agricultural Experiment Station Technical Bulletin 150. 1962.

76. U.S. Dept. of Agriculture. Economics Research Service. Land and water resources: a policy guide. Washington, D.C. Author. 1962.

77. U.S. Census Bureau. Current population reports, Series P-25, No. 251. [from U.S. 18th Census, 1960]. Washington, D.C. Author. 1962.

78. ________, Statistical abstract of the United States. 82nd edition. Washington, D.C. Author. 1961.

79. Saupe, William, Kenneth Joslin, and John F. Timmons. Iowa's disappearing acres--how much? how soon? Iowa Farm Science 18, No. 11: 3-5. 1964.

80. Harland Bartholomew and Associates. Land requirements for urban expansion. Mimeographed. St. Louis, Missouri. Author. 1962.

81. Federal Aviation Agency. National airport plan, 1963-67. Lincoln, Nebraska. Author. 1962.

82. U.S. Census Bureau. Census of Agriculture, 1954. Vol. 1. Part 9. 1955.

83. Denison, Edward F. The sources of economic growth in the United States and the alternatives before us. Committee for Economic Development Supplementary Paper No. 13. 1962.

84. Loomis, Ralph A. and Glen T. Barton. Productivity of agriculture. U.S. Department of Agriculture Technical Bulletin No. 1238. 1961.

85. U.S. Dept. of Agr. Agricultural Marketing Service. Farm labor. Washington, D.C. Author. 1964.

86. U.S. Department of Agriculture. Livestock and poultry inventories. U.S. Department of Agriculture Statistical Reporting Service Bulletin 177. 1963.

87. ________. Stocks of grains, oilseeds, and hay, by states, 1949-60. U.S. Department of Agriculture Statistical Reporting Service Bulletin 304. 1962.

88. ________. Stocks of grains in all positions: Statistical Reporting Service bulletin. Washington, D.C. Author. 1963.

89. Kaldor, Donald R. Rising farm efficiency. Unpublished paper presented at the National Farm Institute, Des Moines, Iowa, February 14-15, 1963. Des Moines, Iowa, Greater Des Moines Chamber of Commerce. 1963.

90. U.S. Department of Agriculture. Changes in farm production and efficiency: a summary report. U.S. Department of Agriculture Statistical Bulletin 233. 1964.

91. Fox, Karl A. Econometric analysis for publis policy. Ames, Iowa, Iowa State University Press. 1958.

92. Rixe, L. C. and H. R. Jensen. Cost advantages to size of farm in Red River Valley farming. Minnesota Agricultural Experiment Station Bulletin 469. 1963.

93. Kimball, N. D. and G. A. Peterson. Economic evaluation of alternatives for developing large dairy farms in Wisconsin. Wisconsin Agricultural Experiment Station Bulletin 571. 1964.

94. Scoville, Orlin J. Relationship between size of farm and utilization of machinery, equipment, and labor on Nebraska corn-livestock farms. U.S. Department of Agriculture Technical Bulletin 1037. 1951.

95. Hoglund, C. R. What size farm or ranch for South Dakota. South Dakota Agricultural Experiment Station Bulletin 387. 1947.

96. Helfinstine, Rex D. Farm plans for wheat farmers in North Central South Dakota. South Dakota Agricultural Experiment Station Bulletin 488. 1960.

ACKNOWLEDGEMENTS

Acknowledgement is made of professional and technical assistance received during the course of the research project. This serves both as a small expression of gratitude to the persons named, and to apprise others of their knowledgeability in the subject area covered, or of their technical skills. All were affiliated in some way with Iowa State University at the time of the study.

Professor Donald R. Kaldor served as major professor and advisor to the author. He provided professional assistance and supervision and gave freely of his time, insight, and experience from the inception of the project through final review of the manuscript. The study benefitted from his perspective and understanding of the problem studied.

Professor John F. Timmons advised and assisted in estimating the supply of farm land in 1980, an early step in the project, while he was chairman of the NC-53 Regional Committee.

Rolf V. Craft conducted the pilot study, assisted in the analysis of farm record data, and in making the 1980 projections. He provided enthusiastic support far beyond his responsibility to the project.

Professors Raymond R. Beneke and Charles W. Meyer provided constructive criticisms and comments concerning the project.

Large volumes of tabulation and computations were efficiently and accurately computed by the Economics Department computing pool, under the supervision of Charlotte Latta.

Norman E. Hutton of the Iowa State University Computation Center wrote and ran computer programs based on the sets of equations described in the thesis. He also served in a similar capacity in the analysis of the farm business records from ten of the thirteen states included in the study.

Patty Maas skillfully typed the manuscript through its several revisions, and Barbara Aycock prepared the final draft for printing.

Acknowledgement solely for the expression of appreciation is accorded the author's spouse for having patiently assumed many of the roles and responsibilities more normally those of the titular head of the family, during the course of this project.

65

629